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**The Welsh Engineers' and Founders' Association**
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## *The Founder on Holiday*

A visitor to this country once described the English climate as consisting of nine months winter and three months rainy weather. The experience of last winter and what for convenience is termed the present summer goes far to justify this impression, heightened because we have been rather spoiled by a succession of brilliant summers. The arrival of a few days of sun and cloudless skies, however, reminds us that after all we are in August, pre-eminently the holiday month of the year, when even the most hard-worked founder may legitimately expect to obtain a little relaxation, and when he applies his mind with greatest difficulty to technical or practical questions.

Does he, we wonder, when on holiday forget his business affairs, or does he come across places and things which remind him of them? We speak of genuine holidays, not business trips away from home, or even abroad. We have all felt outraged when, after a hectic few days full of the fatigues of travel, the difficulties of dealing with a foreign tongue, and the mental strain of observing as much as possible during a brief visit, somebody who stayed at home asks whether we enjoyed ourselves. But such visits are work, not pleasure. On a holiday, pure and simple, does the founder ever cease to found? He can never, perhaps, be so happily placed as the wine-merchant we recall, who ordered while on holiday a bottle of champagne of modest vintage. Finding himself charged twenty-five shillings, he called for the manager, explained his inside knowledge, and showed that half this sum would still leave a generous profit. When the founder takes his family to the seashore, does he show his offspring how to mould particularly elaborate castles in the sand? Does he enable them to win competitions with the aid of intricate cores reinforced with hairpins or wire from ginger beer bottles? Does a chord stir in his memory if he should pass such places as Southport, King's Lynn or St. Erth? If he be a golfer (and sheer vocabulary should give him proficiency in at least one branch of this art), does he speculate on the bonding properties of bunker sand, or on the structure of a steel-shafted club? If he be a motorist, does he deplore the occasional occurrence of a concrete lamp-standard or can he tell when he runs over cast-iron setts? When he refreshes himself at the close of day with the waters of Burton, does he recognise in some ancient hostelry the oven-plate or fire-back that goes back to the dim origins of his craft? At any rate, he can feel himself to be in an old and honourable industry, doing a man's job, and thereby doubly enjoy his relaxation.

## *Asbestos in Foundry Practice*

Foundrymen who have long been familiar with asbestos in the form of gloves, spats and as a roughly-woven cloth, will learn with interest that considerable progress has recently been made in the production of dyed fabrics of various kinds. We had the privilege of inspecting some of these at a private exhibition organised by Bell's Asbestos and Engineering Supplies, Limited, of Slough, last week. The exhibit which appealed to us most was a smart looking boiler suit actually designed for racing motorists, as a protection against fire. It is not within our province to discuss prices, so we know nothing of the cost of this new material. We do know, however, that first cost is not a fair means of comparison, since there are the, as yet unknown factors of wear, ability to withstand repeated washings, comfort in wear and, of course, the highly important fire risk elimination to be considered. We personally tested the fabric in a manner taught to us many years ago by a woollen merchant, and are satisfied as to its inherent strength. Whether, overalls made of such material would be uncomfortably hot or not we are unaware, and await the verdict of the actual user. The curtains of the room housing the exhibition were coloured asbestos fabrics carrying modernistic designs. It occurred to us that, these in their simpler forms could with profit be used in and about pattern shops and stores, whilst automatic drop curtains, operating at 150 deg. F. certainly have their applications where the pattern stores and foundry are contiguous.

A number of patterns of gloves and aprons for use in the kitchens have also been evolved, and in these days when houses may be sold because of the inclusion of a recessed wall soap dish, it occurs to us that manufacturers of cooking stoves might usefully include a pair of gloves as a selling point.

From an examination of the exhibits it is now possible to record that a splendid start has been made in the production of coloured fabrics of various weights. It is acknowledged that it is only a beginning and the potentialities have yet scarcely been fathomed. Enough progress,

(*Concluded on page* 116.)

# Costing Internally-Machined Small Castings

By "RECORDER"

Very often the question arises in the pattern-shop, whether or not certain castings, which have to be machined internally, will ultimately be produced cheaper if the casting be cored or cast solid. The answer will, of course, depend upon the size of the casting. Somewhere, obviously, a limit will be reached where it will be cheaper to machine a cored casting, than to machine a solid casting.

A round cover was required, which had to be machined inside to receive a felt packing ring; the dimensions were roughly 4 in. outside diameter, 3 in. inside diameter, and ½ in. wide. The groove to receive this ring was exactly in the centre of the cover, and allowed a thickness of metal on each side of the groove when machined. As the cover was cast solid the casting was not easily recognised by the rough casting stores. A casting was eventually found however, which most nearly resembled that which was required. This was taken to the drawing office and compared with the drawing. It was obviously found to be correct, but the drawing office argued that it would have been much cheaper if the cover had not been cast solid, but the groove cored out and then machined. The foundryman will no doubt appreciate this suggestion of the drawing office, since the latter design their parts with a view to their influence on costs, but would their suggestion be justified?

Their reasons, of course, are obvious. Firstly—though this can almost be ignored—the cost of material would have been less, and secondly the cost of machining would have been less. Perhaps a first impression would lead one also to take this view, but when the other factors of cost are taken into consideration, it will clearly be seen that the original method used by the patternmaker would eventually produce a cheaper finished casting.

First of all the suggested alteration would involve the making of a new core-box, entailing labour, materials and indirect expenses, plus the making of the core in the core-shop, also involving additional labour, and indirect expenses.

It must be admitted that if the patternmaking and the coremaking are both treated as indirect expenses, the cost as ascertained on paper may be considerably less than the true cost. But an erroneous cost figure is no reason why the pattern shop themselves should not consider all the elements of cost, and make the casting by the method which they think will ultimately be cheaper. The addition of a core would also increase the moulder's time on the job, since the insertion of the core in the mould would take much longer than closing a plain mould.

There is another factor entering into the cost of such castings, which is often overlooked, *viz.*, the cleaning and fettling of the casting in the fettling shop. A plain casting is comparatively simple to clean, but where an internal core is situated in an awkward position, the time spent in cleaning is sometimes very noticeable. In fact, three men have been observed, each in turn struggling hard to remove a piece of obstinate wire left behind when all the rest of the core had been removed. The fact that the fettling shop expenses are included in the overhead charges does not alter the fact that such expenses have actually entered into the total cost of the job.

If the core-box of this proposed new method be examined, it will be noted that ¼ in. would have been allowed all round the thickness of the groove for machining. As the thickness of the groove when finished is only ½ in., this would mean that the width of the groove in the rough casting would only be ½ in. With this in view, the extra cutting which would be required on the solid casting is almost negligible. Furthermore, when the casting is due for machining, a comparative glance of the necessary operations ought finally to convince those who argued that the casting should have been cored that the original method of moulding the cover would ultimately have produced a cheaper finished product.

This casting would require a great deal more attention and care to set up in the lathe chuck. If it could be guaranteed that the cores would be exactly central with the casting then perhaps very little trouble would be caused. But even the machine shops are generally ready to agree, from their own experience, that such a guarantee is highly improbable in small castings. Besides increasing the likelihood of scrapped castings, any variation in machining times would, no doubt, be due to faulty castings!

In conclusion, the results of this brief, but important, observation may be summarised thus:—Where small castings are required which have to be machined internally, the apparent saving in machining the cored casting is not enough to compensate for the additional expenditure which would have been incurred, if the mould was not cast solid.

## Asbestos in Foundry Practice

(*Concluded from page* 115.)

however, has been made to warrant close collaboration by industrialists with the object of affording increased protection to the operatives, whilst maintaining a good order of general appearance in the working clothes.

The manufacturers will welcome suggestions and any problems which may arise from the use of fireproof clothing. Experiments could usefully be made by providing two men on similar duties with overalls, one of asbestos and the other an ordinary boiler suit and then comparing fully the results obtained after a reasonable period of wear. The information gained would be of real value to the industry.

## Düsseldorf Congress

It has been found necessary to change the programme slightly from that previously announced. It is now decided that on Wednesday, September 16, there will be a number of works visits, whilst at 11.30 a.m. on the following day, the official opening of the Congress will take place, followed in the afternoon by the official visit to the Foundry Exhibition. On Friday and Saturday, September 18 and 19, there will be synchronous technical sessions in the mornings and works visits in the afternoons, and on Sunday there will be further technical sessions. Additional details may be had on application to Mr. T. Makemson, St. John Street Chambers, Deansgate, Manchester, 3.

## Electricity Returns

Official returns made to the Electricity Commissioners show that 1,403,000,000 units of electricity were generated by authorised undertakings in Great Britain during July, compared with the revised figure of 1,216,000,000 units in the corresponding month of 1935, an increase of 187,000,000 units, or 15.4 per cent. The number of working days in the month was the same in each year. During the first seven months this year the total amount of electricity generated by authorised undertakings was 11,294,000,000 units, compared with 9,720,000,000 units for the corresponding period of 1935, an increase of 16.2 per cent.

**Correction.**—Mr. A. Sutcliffe informs us that the trough to which he referred in his discussion on Mr. Hudson's Paper was two feet wide and not two inches as printed.

# The Spelter Situation

By "ONLOOKER"

In the modest appreciation of the values of non-ferrous metals which has occurred this year, spelter has had its share, but it has been obvious to everybody that "Cinderella" has been lagging behind the others, and one has only to look at the margin between lead and spelter to realise this. For years, of course, spelter was valued over lead, but in this respect at any rate the times are out of joint, and for a long time past the position has been reversed, spelter being the lowest priced of the non-ferrous quartette. The reversal of the position of these two metals has been due to two factors; the excellent demand for lead, and some tailing off in the consumption of spelter. There is, however, more than this behind the present relationship between the two metals, and it is a matter which is exercising the minds of many people both off and on the metal exchange.

When the change from an *ad valorem* to a fixed duty was made it was hoped by those responsible for the alteration that more business would accrue to Whittington Avenue, and consumers were asked as far as possible to help in this matter. It seems doubtful whether any advantage has been gained, for anyone buying on the metal exchange is left in doubt as to what he is going to get; all the buyer can be sure of is that he will receive some kind of G.O.B. spelter, but it may easily turn out to be a brand unsuitable for his work.

### Effect of Duty Revision

The duty revision, therefore, has not helped much, and had it not been that strong hopes were entertained that the Zinc Cartel would come into being again the quotation might well have declined a good deal further than in fact it did. Now, however, this prop seems to have been dashed aside, and at the present time the prospects of getting the cartel on its feet again are decidedly poor. The market has reacted sharply on this news, and it is very difficult to say how far the decline will go, for all sorts of reports are in circulation, and, of course, it may prove that there is some hope for the cartel after all. One suggestion is to the effect that there will be a demand for a higher rate of duty, but just how this is going to help remains to be seen, for in the past we have found that the effect of really adequate protection for the home producer has been in the direction of depressing values on the metal exchange.

It is very difficult to be optimistic about the prospects for spelter, although one must admit that the price to-day is very moderate and might well stand higher without proving a deterrent to consumption. The trouble is that consumption is not on too good a scale, while production is apparently still on the upgrade. This is perhaps the most disturbing factor for those who would like to think that spelter is worthy of a higher price level, for if production is sufficiently profitable at ruling prices to encourage output, then there seems to be little hope of getting the quotation any higher.

Conversely there is obviously room for a fall since the upward trend in stocks cannot fail to exercise a depressing effect on values, as metal, in the absence of consumers' demands, is pressed for sale on the London market.

Spelter is found in many different places on the earth's surface, and the British Empire is well blessed in supplies of this metal. Much of it is produced in the electrolytic form, although the bulk of what is manufactured in this country comes from retorts. It is generally agreed that this home production, even though it comes from imported concentrates, must be fostered and encouraged, for apart from this we are entirely dependent upon supplies from overseas.

# Corrosion and its Relation to Grey-Iron Casting Production

By FRANK HUDSON (Oliver Stubbs Medallist)

*This Paper was presented on behalf of the Institute of British Foundrymen to the Polish Foundrymen's Association. The Author is Chief Metallurgist to Glenfield & Kennedy, Limited*

*"The wastage of metals due to corrosion has become an important engineering problem. Probably no other source of waste, except that affecting human life, is of greater concern to all."—(Speller[1].)*

The above text introducing Dr. Speller's admirable book—"Corrosion, Causes and Prevention"—aptly expresses the position to-day relative to the loss occasioned by the corrosion of engineering structures made from iron and steel. In 1922, Sir Robert A. Hadfield[2] assessed the annual world wastage due to corrosion as being over £700,000,000. This enormous loss has undoubtedly provided much food for thought to metallurgists and engineers during the past 14 years, and a large amount of work has been conducted in combating corrosion through research and preventive engineering.

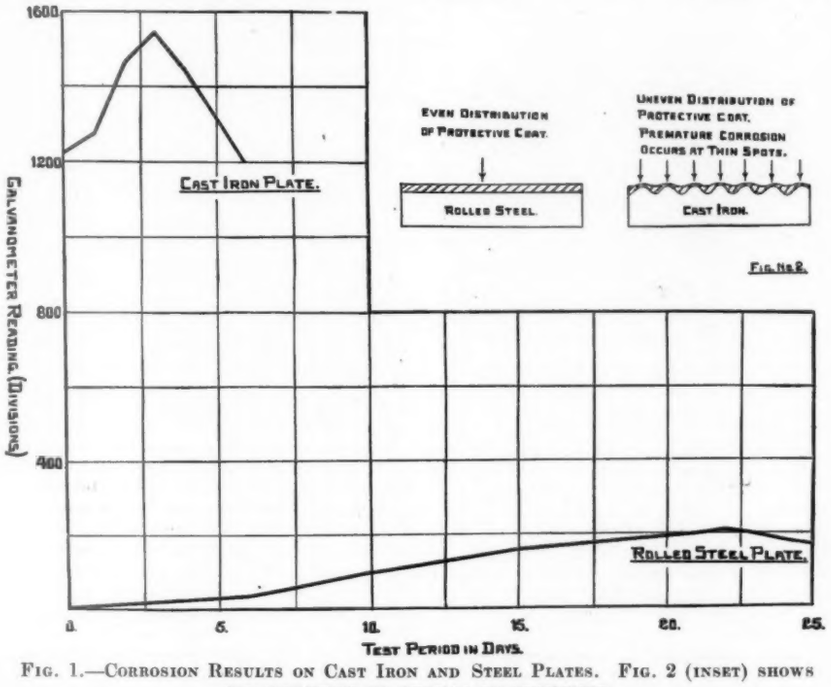


Fig. 1.—Corrosion Results on Cast Iron and Steel Plates. Fig. 2 (inset) shows the influence of surface on resistance.

In this work the foundryman has played an important part, and with the increasing developments of the age, is likely to play a still greater part in the future. Probably during the past few years more has been done in controlling the ravages of corrosion, so far as iron and steel are concerned, by the use of improved protective coatings of various kinds, together with the removal of the cause of the trouble, such as in the deoxidation and prevention of turbulent flow in water, than by a solution along purely metallurgical lines. In making this statement, however, it is not intended to belittle the work of metallurgists nor under-estimate the value of the wonderful modern corrosion resistant alloys produced since the discovery of stainless steel by Mr. Harry Brearly in 1913. Logical thought must give these new alloys second place, inasmuch as they are expensive and consequently can only be extensively used for the construction of the larger engineering structures when price is a minor consideration.

Furthermore, the corrosion problem is likely to receive minute consideration in the future in connection with mechanical wear. The Institute of Automobile Engineers has already investigated this aspect in relation to the internal-combustion engine, and its report clearly attributes wear as being largely due to corrosive influences.

It is thus evident that corrosion bears a definite relation to iron casting production, inasmuch as the foundryman has to produce firstly a relatively cheap casting which can be given a satisfactory degree of corrosion resistance by the application of some kind of protective coating, and secondly to supply when required alloy iron castings having the necessary corrosion resisting properties by virtue of composition.

In the present Paper an attempt will be made to discuss in a practical manner the more pertinent points connected with the above so far as the foundryman is concerned.

## Factors Connected with the Production of Iron Castings which have to Subsequently Receive a Protective Coating

Probably the major portion of iron castings produced for service to mankind receive at some time or another the application of a protective coating to preserve them from corrosion. The type of coating commonly employed ranges from tar or bitumen compounds extensively used for the treatment of such castings as water-pipes, valves, etc., for service underground, to the various paint finishes, and if maximum corrosion resistance is to be obtained certain relationships between castings and the applied coating must be kept in mind.

In the first place it is not generally appreciated that the "as-cast" surface skin of all iron castings has usually a greater resistance to corrosion than the underlying metal due to its coating of iron oxide. This serves, to some extent, as a natural protective coating, and gives rise to the resistant "skin effect" often noted when studying the effects of corrosion upon iron castings. It is also probable that there exists, immediately below this oxide skin, an extremely thin layer of metal having superior corrosion resistance to that in other parts of the casting. Consequently, in order to obtain maximum corrosion resistance, it is of some importance to ensure continuity of this surface skin as far as possible.

This statement particularly refers to the needless practice in some foundries of running the grindstone over the surface of large castings for no apparent purpose. Even when the castings are to be dipped in tar or painted, the above still applies, for this natural protective skin forms an excellent base to augment and further improve resistance against corrosion. An investigation into this matter will be well worth while, as it is probable that suitable treatment of the mould face may lead to the production, on the casting, of a more permanent protective skin capable of resisting corrosion without the application of external means.

Fig. 3.—Structure of 80-year-old Cast-Iron Pipe. Polished. × 100.

As well as ensuring continuity of the casting skin, the question of surface finish is of great importance. In a recent investigation conducted by the author upon the protection afforded to iron and steel structures by various paint films, etc., it was found generally that any particular paint afforded superior protection to rolled steel than to cast iron. The method adopted for these tests is known as the *galvanic couple test*.[3] The procedure followed is to cover a mild-steel or cast-iron plate of defined area with the paint to be tested. After the painted section is dry it is immersed in any particular solution between two graphite electrodes of the same area as the sections under test. The small electric current generated by this couple is measured on a sensitive galvanometer, the first reading being taken after ½ hr. with an open circuit and then at 24-hr. periods, during which time the graphite plate and section under test have been in a closed or short circuited state. The test is discontinued when (*a*) any sign of rust appears, and (*b*) any abrupt alteration occurs in the current flowing.

The metallic plates used in the test are 8 in. by 10 in. by ⅛ in. thick, and they are coated by dipping to ensure comparative conditions as far as possible.

Fig. 1 illustrates the results obtained by this method on cast-iron and rolled-steel sections protected with a tar dipping solution. It will be observed that the current generated by the cast-iron plate reached a maximum in three days in comparison to 22 days for the rolled-steel section, and the amount of current generated was over seven times greater. These figures clearly indicate that the protected cast-iron plate begins to corrode earlier and to a much greater degree than the steel sections. The reason for this is entirely due to the surface

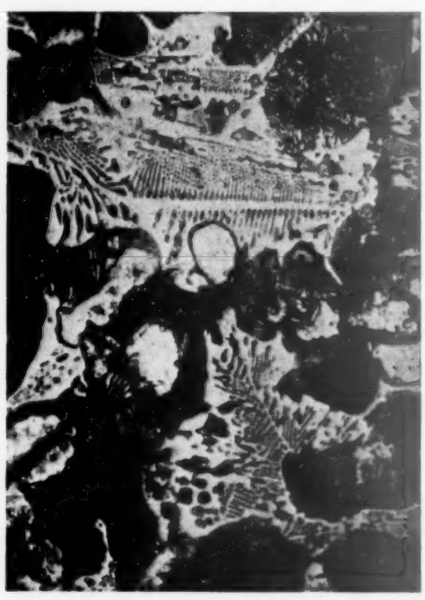

Fig. 4.—Structure of 80-year-old Pipe. Etched. × 100.

finish of the specimens employed. In the case of the steel specimen, this has a relatively flat surface, and the protective coating of tar, etc., is of equal thickness over the whole section. In the case of cast iron, even with castings that can be classed of good commercial finish, the surface is not smooth, and this gives an uneven distribution of the protective coating employed, with consequent premature corrosion at the thin spots, as shown diagrammatically in Fig. 2.

The obvious conclusion to be drawn from this test is that the better the surface finish on iron castings which have subsequently to receive a protective coating, the greater the resistance to corrosive attack.

There are other more obvious factors which come under a similar category to the above when considering the question of corrosion and its relation to iron casting production, such as the presence of defects, solidity, etc., but space does not permit their consideration in this Paper, except to state that all castings required to resist corrosion should be as sound and clean as it is possible to make them. Corrosion tends to penetrate along cracks, if they occur, whilst porosity or non-metallic inclusions are very liable to promote attack.

### The Corrosion of Cast Iron and the Effect of Alloy Additions

*Forms of Attack.*—The mechanism of corrosion in cast iron is a problem, which even to-day one knows relatively little about. Commercial cast iron shows great variation in regard to its resistance to corrosion. Sometimes it has a surprisingly long life, whilst in other cases the exact opposite applies. A few installations of cast-iron pipe in France were found to be in good condition after 160 years of service.[4] In 1933 the author examined a portion of a cast-iron pipe excavated at St. Germans Pumping Station, King's Lynn, reported to have been in service for 80 years. The analysis of this pipe was found to be as follows:—T.C, 3.30; C.C, 0.50; Gr, 2.80; Si, 1.73; Mn, 0.30; S, 0.04; P, 1.45 per cent.; Ni and Cr, faint trace.

The section submitted was surprisingly free from corrosion, and had a tensile strength of 10 tons per sq. in., with a Brinell hardness varying between 163 to 179. The photomicrograph, Fig. 3, illustrates the structure at 100 magnifications in the "as-polished" state, and it will be noticed that the graphite exists in the form of large continuous flakes. The photomicrograph, Fig. 4, shows the structure after etching. A point of considerable interest in this latter photograph is the clarity of the pearlitic laminations at low magnification, a factor not usually obtained in modern grey-iron practice. The purpose in bringing forward this example is to indicate that here is an iron casting which to-day might be considered only of medium quality, and yet it has withstood corrosion influences for 80 years without appreciable deterioration.

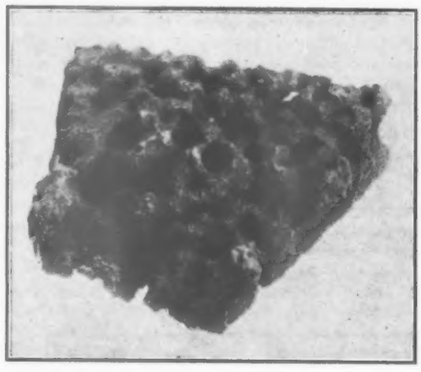

Fig. 5.—Typical Example of Corrosion Attack by "Pitting."

Other cases have occurred, however, where cast iron has failed after only a few months exposure. Instances are known of foundry complaints from engineers relative to the premature failure of pipes through perforation and suggesting that these were due to defects filled up with iron cement, whilst actually the trouble was entirely a question of localised corrosion attack accentuated by environment. When corrosion of cast iron occurs at *a rapid rate*, the attack usually takes one or other of two forms—pitting, which might subsequently develop into complete perforation of the casting, and secondly, that type of corrosion known as "graphitic softening." Usually only certain parts of the castings are affected and this is often no doubt responsible for the engineer's opinion as to the cause being due to foundry defects. Fig. 5 illustrates a typical example of "pitting" in a section of grey cast iron working in contact with water. Only part of the casting was corroded in this manner, and the localised attack is entirely due to turbulence and the consequent variation in the oxygen content of the water from one part of the casting to another. This form of corrosion is typical of electro-chemical action brought about by what is known as anodic attack of the differential aeration type.

In Fig. 6 an example is given of the second form of corrosion which grey cast iron is subject to under certain conditions, namely that of "graphitic softening." This casting is a piston from a certain piece of hydraulic machinery which was returned as defective after a few months' service. Half of the piston was in satisfactory order but the remainder was badly corroded and could be quite easily cut with a knife. The analyses of the affected and unaffected areas are as follow:—

| | Unaffected Area. | Corroded Area. |
|---|---|---|
| T.C per cent. .. .. | 3·46 | 16·63 |
| Gr. .. .. .. | 2·72 | 13·25 |
| Si .. .. .. | 1·87 | 2·82 |
| Mn .. .. .. | 1·03 | 2·52 |
| S .. .. .. | 0·065 | 0·12 |
| P .. .. .. | 0·19 | 0·75 |
| Balance .. .. .. | Iron | Iron and Rust |

The photomicrograph Fig. 7, taken at 40 magnifications, shows a section through the corroded area. Apparently the corrosive attack has caused the iron to be removed with the consequent building-up of the graphitic carbon. It will also be observed that the attack, in this example, has penetrated into the metal along the graphite flakes. The trouble is again a question of electro-chemical action and is very often produced by stray electric currents. "Graphitised" iron retains its original form and if left undisturbed it is quite strong enough to carry water under low pressure but is likely to fail under shock.

Sea water in time appears to affect cast iron in this manner, and there are interesting examples on record in connection with this form of corrosion. In 1856, guns were raised from the "Mary Rose," an English man-of-war sunk by the French and found near Portsmouth in 1847. These cannon were of wrought iron bars hooped with rings of the same material, and were all loaded with grey cast-iron cannon balls. The guns were non-graphitised, but the cast-iron balls, which should have weighed 30 lbs. and 70 lbs. respectively, only weighed 19¼ lbs. and 45 lbs. Their appearance was like that of regular shot when first brought up from the sea, but they gradually became hot and fell to pieces on exposure to air.

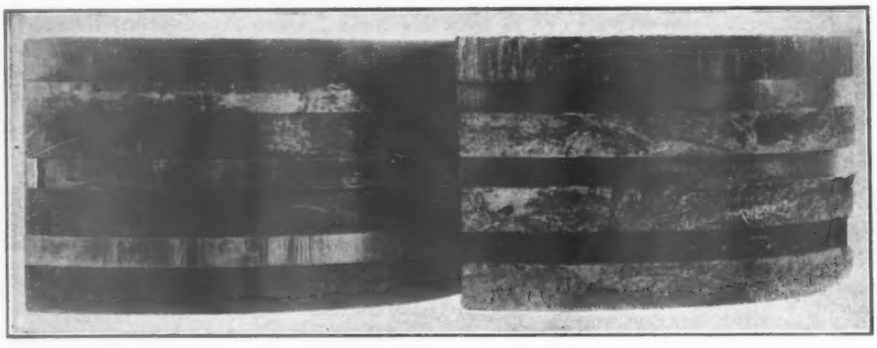

Fig. 6.—Typical Example of Corrosion Attack by "Graphitic Softening." The Section on right is attacked and can be easily cut with a knife.

Apart from the corrosion of cast iron by "pitting" and by "graphitic softening," the only other form of attack is the most common

of all, namely, the liability of the ferrous metals to form rust. This may seem a very obvious point to bring up, but it will repay some thought when considered as a possible source of the depreciation of such important castings as cylinders, etc., and other parts of machinery operated by internal combustion, steam or hydraulic power. In all of these instances corrosive products are formed during operation, and research clearly indicates that the elimination of wear will be obtained by a study of the corrosive resistance of the metals employed rather than by hardness.

### Mechanism of Corrosion

The foregoing remarks will no doubt be sufficient, considering the text and scope of this

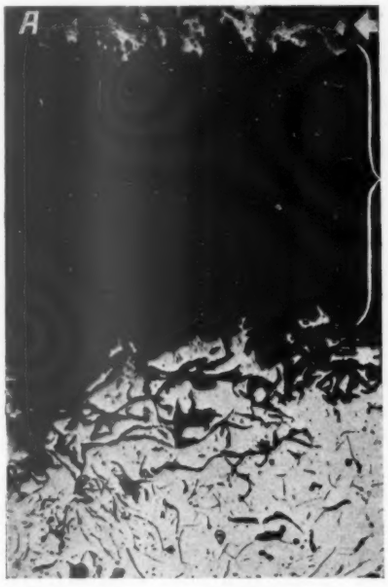


Fig. 7.—Micrograph through Graphitised Area as shown in Fig. 6. A is the Mounting Material, whilst between brackets there is an Outer Layer of Graphitic Carbon and Rust. Polished. × 40.

Paper, to give the foundryman some idea of the way cast-iron articles are affected by corrosive attack. The next question is in what way cast iron can be improved to give better service in this direction. Obviously, no complete answer can be given in view of the wide discussion entailed, but some ideas may be obtained by consideration of the following points. First, it should be understood that when any metal is subjected to corrosive influences, the surface of the metal undergoes a change and the nature of this change is directly connected with both the composition of the metal and the attacking corrosive influence.

For example if cast iron is subjected to atmospheric corrosion and to corrosion by complete submersion in water quite different results will be obtained. The atmosphere contains 21 per cent. oxygen by volume whilst water as a rule will not contain more than 1 per cent. of oxygen. Consequently the film of rust formed by these different methods of attack also varies. When iron corrodes in the atmosphere the rust formed has mainly a ferric-hydroxide base, whilst when formed under water the corrosion products often contain a large proportion of iron in the ferrous condition. This latter form of rust usually gives a very loose and non-adherent coating which will not act as a protective coating to the metal underneath. In the case of the rust film formed by atmospheric attack, this is much more adherent and may in some instances actually help to protect the underlying metal.

In 1908, Dr. Speller, in examining some old metals which had been left in the Isthmus of Panama since 1888, found many instances where pipe which had not been protected in any way by artificial coatings was in excellent condition, having apparently acquired a natural film of oxide. This oxide was probably formed during the hot dry season. Samples of this pipe, after having this natural coating removed, rusted badly in a few months. The same reactions are made use of in the Bower-Barff process for applying a protective coating to iron and steel articles.

The addition of certain alloys to ferrous metals causes a change to occur in the properties of the protective film formed. For example, the presence of a small amount of copper gives a more adherent, denser and smoother rust coating when allowed to corrode in the atmosphere, with the result that less attack takes place. For service underwater or underground, however, this effect of copper is much less marked and the addition is of very doubtful value. On the other hand, the effect of chromium is to produce an oxide layer of much greater permanence and consequently protection against corrosion is obtained over a wider range of conditions. The addition of nickel as well as chromium gives rise to the formation of a still more resistant coating. It will thus be observed that the corrosion product or film first formed has an important bearing upon subsequent

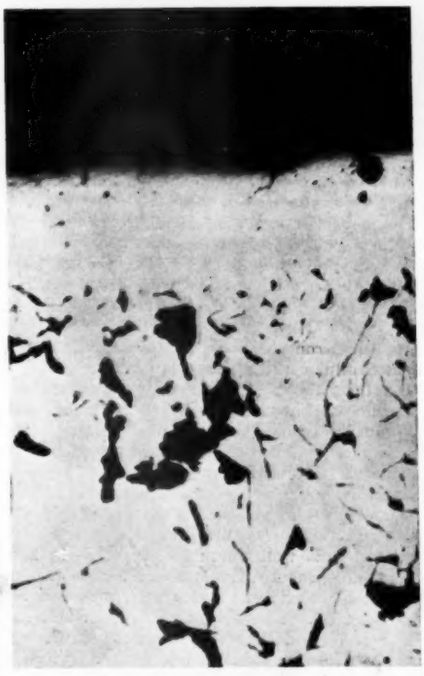

Fig. 8.—Surface Structure of Grey-Iron Casting. Polished. × 250.

attack, and as previously mentioned the properties of this film depend upon the reaction between metal and corroding medium. In view of the wide variation in composition of the metals employed in industry to-day and the large number of corroding media the selection of suitable materials of construction entails long and patient research. In regard to the general mechanism of corrosion it may now be regarded as established that in substantially all cases of corrosion at ordinary temperatures the driving force of the corrosion reaction between metal and environment is electro-chemical. Briefly, the factors which require consideration in connection with the corrosion of metals can be detailed as follows:—

(1) *Factors associated mainly with the metal:*

(*a*) Effective electrode potential of a metal in a solution.

(*b*) Over-voltage of hydrogen on the metal.

(*c*) Chemical and physical homogeneity of the metal surface.

(*d*) Inherent ability to form a protective film.

(2) *Factors which vary mainly with the environment:*

(*a*) Hydrogen -ion concentration in the solution (*p*H value).

(*b*) Influence of oxygen adjacent to the metal.

(*c*) Specific nature and concentration of other materials adjacent to the metal.

(*d*) Rate of flow of the solution in contact with the metal.

(*e*) Ability of environment to form a protective deposit or coating on the metal.

Fig. 9.—Surface Structure of Grey-Iron Casting. Etched. × 250.

(*f*) Temperature.

(*g*) Cyclic stress (corrosion fatigue).

(*h*) Contact between dissimilar metals or other materials as affecting localised corrosion.

All of the factors just mentioned are receiving very careful study in engineering works' laboratories and in British Universities, and they have been mentioned in this instance only as an object lesson to indicate the futility of assumptions in connection with any problem connected with corrosion. From the foundrymen's point of view the points of particular interest are 1 (*c*) and 1 (*d*).

### Chemical and Physical Homogeneity of the Metal Surface

At the beginning of this Paper some mention has been made of the more practical aspects requiring consideration in the production of grey-iron castings for resisting corrosion. What of the metallurgical side? White cast iron generally resists corrosion better than grey cast iron and malleable iron is not subject to graphitic corrosion. From this one would imagine that the nature of the graphite network is of importance. Speller[5] states:—"In grey cast iron the graphite and cementite ($Fe_3C$) form the cathodes of small electrolytic cells with the ferrite crystals as anodes so that, when immersed in salt water or underground, such cast iron is likely to undergo graphitisation. The presence of cementite in grey cast iron affords the ferrite some mechanical protection against graphitic corrosion

as the cementite itself is not readily dissolved. It also produces a much smaller difference in potential with the ferrite than does graphite."

This statement is not altogether borne out in actual practice. In general, ordinary grey cast iron has a considerable degree of resistance to underground corrosion, as is evidenced by the example of the 80 year old water pipe given earlier. Furthermore, it cannot be claimed with any degree of certainty that mild steel has a greater degree of corrosion resistance than grey cast iron, and in view of these facts one has very great difficulty indeed in seeing the importance of the graphite network. During the past few years the author has conducted a large number

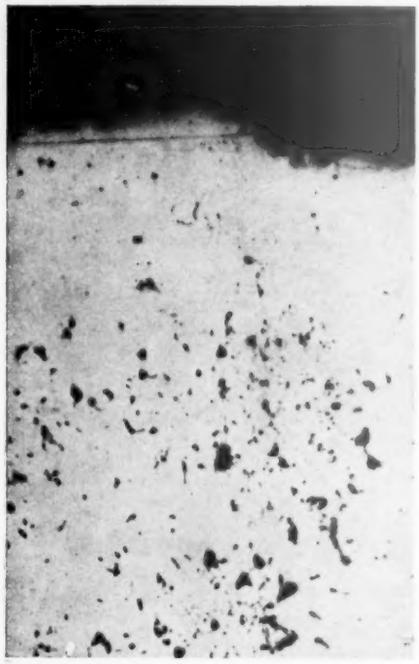

FIG. 10.—SURFACE STRUCTURE OF CASTING IN AUSTENITIC IRON. POLISHED. × 250.

of corrosion tests and has been privileged to examine a large number of corroded cast-iron articles, and in reviewing the results obtained it has not been found possible to draw any practical conclusion whatsoever relative to the effect of the graphite network upon the degree of corrosion present.

In fact, it would appear that in the range of commercial grey iron castings produced to-day the size and distribution of the graphite is not of extreme importance in regard to the practical problem of corrosion. Laboratory investigation may disclose some slight effect of the graphite network on corrosion, but in most instances this is of such small magnitude as to have little effect upon resultant service. The presence of graphite may certainly accelerate the corrosion of grey cast iron under certain conditions of service, but alteration of the size and distribution of the graphite will probably not overcome the trouble to any appreciable degree.

Variation of the composition of grey cast iron within the general limits of carbon, silicon, manganese, sulphur and phosphorus commercially employed to-day also does not seem to have any spectacular effect upon corrosion, and the development of a corrosion-resisting material definitely resolves into a research upon the value of protective coatings and alloy additions.

### Protective Coatings and Alloy Additions

Both these factors are intimately connected. Every foundryman is perfectly familiar with the use of protective coatings such as paint, tar or bitumastic compositions, etc., for coating grey-iron castings to enable greater corrosion resistance to be obtained. Some mention has also previously been made of the value of the natural oxide skin common to all iron castings in this direction. If a careful examination be made of the cast surface of a grey-iron casting it will be found that immediately below this oxide skin there exists, in the majority of cases, a narrow band of metal containing no free graphite flakes, as shown in the photomicrograph, Fig. 8. This section was taken from the 1-in. thick flange of a water pipe, cast in green sand, having the following composition:—T.C, 3.47 per cent.; Gr., 2.87; C.C, 0.60; Si, 1.92; Mn, 0.78; S, 0.098; P, 0.26 per cent.

The thickness of the graphite-free layer approximates to about 0.003 in., and theoretically this, together with the natural coating of oxide, should have a higher degree of corrosion resistance than the underlying metal and so act as a protective coating. Actually it does to some extent in certain corrosive media, such as water, but it has been found that in many cases the effect is not uniform to the whole casting, which prevents its full value being obtained. The presence of this layer has in the past been overlooked by most investigators, and consequently has not received the consideration it merits. The photomicrograph, Fig. 9, illustrates the surface after etching with picric acid. It will be observed that the graphite-free band is attacked by acids to the same extent as the base metal, indicating in a general way that there is no large difference in corrosion resistance between the two when corrosion attack is severe. The presence of this surface layer is, however, of outstanding interest, as it is probable that by the addition of certain metals or alloys to either the mould surface or the iron itself, it might become possible to obtain a uniform protective coat having a high resistance to corrosive attack. The author's investigations in this direction are as yet too incomplete for publication, but there is no doubt whatsoever as to the possibilities.

The photomicrographs, Figs. 10 and 11, show the surface structures present on a section of austenitic cast iron having the following analysis.—T.C, 2.74; Gr., 2.32; C.C, 0.42; Si, 1.55; Mn, 1.35; S, 0.049; P, 0.13; Ni, 16.82; Cu, 7.93; Cr, 0.66 per cent.

The effect of the alloy additions has been to increase in thickness the graphite-free band up to 0.004 to 0.005 in. and promote uniformity over the casting surface. Furthermore, after etching it is obvious that the corrosion resistance of this surface layer is outstanding and actually superior to the base metal.

Investigation may possibly disclose that small alloy additions to the iron have the property of stabilising this surface layer to a marked degree, and it is well worth keeping this in mind as a possible future development in the production of a relatively cheap corrosion-resisting grey cast iron. The obvious failing in this suggestion is its inability to protect machined surfaces, but in many instances, such as pipes or valves, the machined surface is not in contact with the corroding medium. In those cases where machined surface must be protected from corrosion, recourse will have to be made to either austenitic or 30 per cent. chrome cast iron.

A certain amount of work has been conducted during the past few years on the effect of alloy additions to cast iron from the corrosion-resisting viewpoint, and this has resulted in the development of three cast irons having a marked resistance to corrosion. The production of cast iron containing between 11 to 17 per cent. silicon is probably the first and oldest method in successful production, but the disadvantage of castings made in this way is that they are very brittle and hard, and this has hindered extensive application. The second development was the production of austenitic cast iron, the use of which at present is rapidly extending in many directions, and, lastly, there is the more recent discovery of 30 per cent. chrome cast iron. These three materials give excellent service in many directions, and have been fully described in the technical Press at various times, and it is not proposed to deal with them further in this Paper. These three irons are, however, somewhat expensive, due to the large percentage of alloys they contain, and also because of the greater difficulties encountered in production. This has quite naturally led to research into the use of cheaper alloys, but so far nothing has yet been produced capable of comparison. Success in this direction might ultimately be found by investigation of the iron-carbon alloys containing between 1.0 to 2.5 per cent. carbon. Ferrous metals within this range have received surprisingly little attention, and they undoubtedly

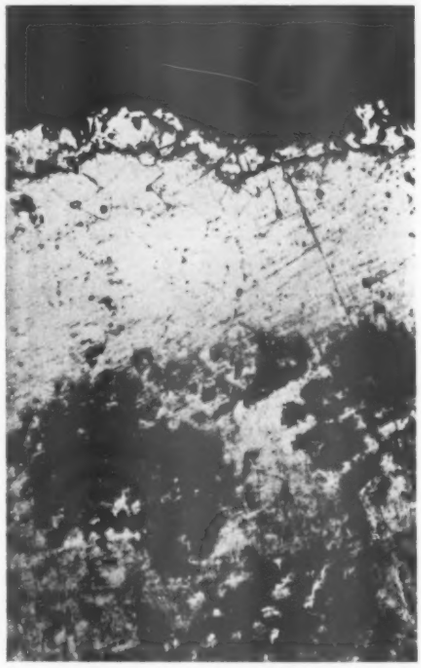

FIG. 11.—SURFACE STRUCTURE OF CASTING IN AUSTENITIC IRON. ETCHED. × 250.

hide untold future possibilities. In fact, the successful commercial production of the 30 per cent. chrome irons will ultimately be due to experiments conducted along such lines.

### Summary

Grey cast iron is subject to certain types of corrosion attack, and typical practical examples have been given. In the majority of cases this attack is not connected with production methods and is essentially due to service conditions. The foundryman can help in some degree to combat the ravages of corrosion by attention to casting finish, by keeping the surface skin unbroken, as far as possible, and by ensuring the production of castings free from defects. Modification of the normal composition of grey cast iron is not likely to have any great effect upon obtaining improved resistance, and at the present time the only positive way of minimising attack is to employ one of the recognised corrosion-resisting alloy cast irons. These are relatively expensive for many applications and more economical developments might readily be obtained by a serious investigation into those factors connected with the production of a corrosion-resisting skin and the effect of alloy additions upon ferrous metals containing 1.0 to 2.5 per cent. carbon.

REFERENCES

[1] Dr. F. N. Speller, "Corrosion, Causes and Prevention."
[2] Sir Robert A. Hadfield, Proc. Inst. Civil Engineers, p. 121, 1921-22.
[3] W. P. Digby and J. W. Patterson, "The Engineer," June 8 and 15, 1934.
[4] J. N. Friend, Iron and Steel Inst. Carnegie Schol. Mem. p. 81, 1922.
[5] Dr. F. N. Speller, "Corrosion, Causes and Prevention," p. 73.

# Moulding a Cast-Iron Stool for a Pump Motor*

By H. GREENHOUSE

The casting shown in Figs. 1 and 2 formed the baseplate for a 1,500-h.p. vertical pump motor, and was part of the equipment required for the large graving-dock at Southampton. Its diameter on the outside flange is 10 ft. 6 in.

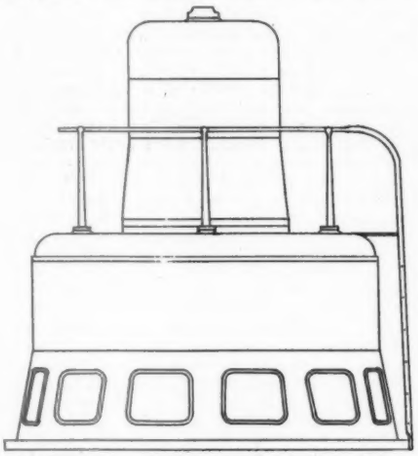

Fig. 1.—Outline Sketch of Vertical Pump Motor, showing the Cast-Iron Baseplate.

(approximately), tapering down to 8 ft. 10 in. at the bottom flange, and the overall depth is 2 ft. 4½ in. The rim, which has a bore of 6 ft. 1 in., is connected to the outside casing by means of a plate, and ribs of various dimensions. The outside wall is lightened by a series of panel holes. Several of these castings had to be made, and they were considered to be particularly suitable for strickle moulding.

It was decided to make such tackle as would not only be suitable for this job, but would also be useful for general foundry practice, and accordingly a bottom plate, top plate, two binding rings and fifty bars were made.

The centre-spindle used was a standard 3-in. turned bar, and the centre-plate was firmly bolted to the bottom-plate (Fig. 3). A flange was cast round the bottom-plate to receive the ends of the support bars, as, by using this type of tackle, the mould was easy to stove and to place in any position for casting. Thus, the main

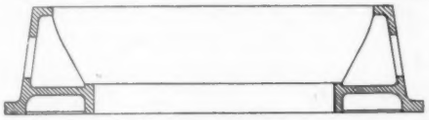

Fig. 2.—Section through Baseplate.

structure of the outside of the job did not require re-making for each subsequent casting. The section of the mould inside the bottom flange was loosely built up of checkered brickwork, filled in with ashes and a 3-in. layer of stiff loam placed on the top. It was built up in this fashion to allow primarily for the contraction of the casting, and also permitted the bottom-plate of the core to be dropped upon the bottom-plate of the mould. The casting was run by two down-gates, each 2 in. sq., and the ingates were branched to strike the outside of the bottom flange at a tangent.

For making the binding rings, a mould was made, 13 ft. 3 in. outside dia., 11 ft. 3 in. inside dia. and 3 in. deep, with fifty cored holes, 4 in. by 2 in., equally placed around it. The first ring was cast 1½ in. thick, and the second, some thirty minutes afterwards, on top of the first. These rings were placed approximately 15 in. apart, and the down-gates were bricked up in the job. This process was continued until the top ring was reached, the brickwork being filled up with ashes and rough bricking loam,

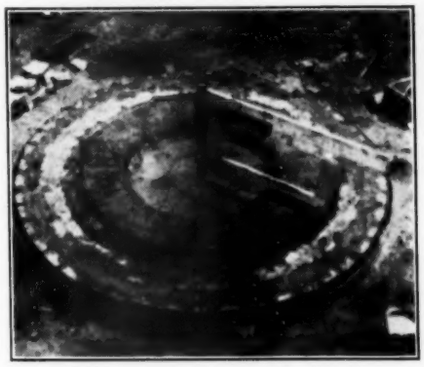

Fig. 3.—Initial Set-up of Tackle for Strickle Moulding the Baseplate.

which consisted of four parts of floor sand to one part of red sand and no manure.

The method successfully adopted for making up sections of a mould was to ram the portion up with a fairly strong bonded core sand instead of using very stiff loam. By this method neither an undue number of cracks, nor the distortion that sometimes accompanies the usage of stiff loam were experienced, and much time was saved in striking up the whole job.

Fig. 4.—Lifting Plate, Core Iron and Strickle in Position.

It was decided to strike the core up in one piece, as this method made for single lifting, and enabled a more rapid and accurate coring of the mould. It was realised, however, that, on account of the design of the core, it could not be carried by an ordinary core iron, which would probably have caused springing and distortion when the core was lifted in its green state. To overcome the difficulty a cast-iron lifting ring was used, the core grid being placed on this ring and the core built up. Fig. 4 shows the lifting plate, core iron and strickle set in position.

It must be pointed out that the core was so made as to allow unchecked contraction of the

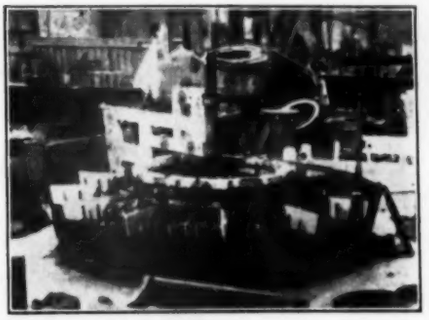

Fig. 5.—Showing Centre Retaining Ring of Brickwork.

casting. A centre retaining ring of loose brickwork, 4 ft. dia., was built for a certain height, the reasons for which will be explained later, and above this, solid brickwork was carried up to

Fig. 6.—Core Prior to Stoving.

the joint of the mould (Fig. 5). The ribs were set by means of templates and gauge plates, ashes were freely used, and when poured the gases were led to the centre retaining wall of

Fig. 7.—Top Part of Mould, showing the Twelve Ribs.

checkered bricks, and escaped up the centre which was not rammed up.

The core in a semi-finished condition before stoving is shown in Fig. 6. It will be noticed that a belt had been struck round the outside

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* Entry in a Short Paper Competition held by the Birmingham Branch of the Institute of British Foundrymen.

of the core, and into this were cut twelve arms which formed panels round the core. These arms were cut into the core permitting the centre line of the connecting ribs to be used as centres for the arms. By suitable arrangement these arms could be cut into the core, leaving the mould

Fig. 8.—Finishing Coat of Loam applied to the Top Part.

itself neat and clean to form the outside of the casting. The large ribs were not drawn until the core was in its final drying position.

Fig. 9.—Core in Position.

The top part of the mould had twelve ribs, illustrated in Fig. 7, to correspond to the twelve ribs and arms in the core, thus forming twelve copes on the top. Gases were led through suitable holes in the plate.

Fig. 8 shows the top part after a finishing coat of loam had been applied. The outside finger-print sweeping round the plate was used for setting the top part over the bottom portion of mould. A portion of supporting loam was cut away to allow a better view of the centre lines when closing the mould. The two down-gates were led through the top plate to connect up to the down-gates on the bottom of the mould which were broken on the joint to bring them into a smaller runner box.

Fig. 11.—The Mould closed and weighted ready for Casting.

Fig. 9 shows the core in its correct position with four small lugs used to pick the casting out of the mould without disturbing either brickwork or rings. A cross-section of the mould when closed is illustrated in Fig. 10, which shows the extra brickwork to support the centre bore at the top, the down-gates, risers and core-grids.

When ready to cast, the mould was held down by sixteen ton weights (Fig. 11); the runner box measured 24 in. by 16 in. by 8 in., and six risers, three of which were on the inside bore were used. The average casting times for the castings was 1 min. 27 secs.

After the job was cast, the weights were taken off, and the loose checkered brickwork removed from the bottom of the moulding plate. This enabled the core plate to drop down on to bottom plates below the flanges of casting so that the whole core collapsed.

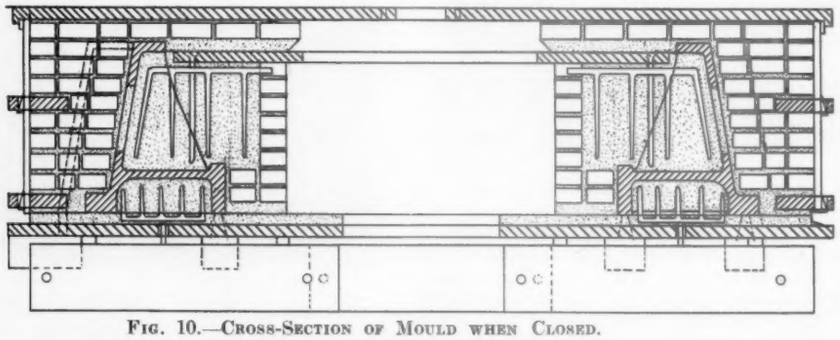


Fig. 10.—Cross-Section of Mould when Closed.

### Definition for Cast Iron

At a recent meeting of the metallurgical advisory committee to the National Bureau of Standards, United States Department of Commerce, the following tentative definition of cast iron, modified in accordance with the suggestions of the committee, was considered by the Bureau: "Cast iron is a cast alloy of iron and carbon, with or without other elements, in which the carbon content exceeds the maximum limit of solid solubility, as determined at any temperature (which in plain cast iron is 1.7 per cent.) and, hence, contains eutectic carbide or graphite as a structural feature. It is not usefully forgeable at any temperature."—"The Iron Age."

# Collection and Analysis of Air-Borne Dust

At the Summer Meeting of the Institution of Mining Engineers held recently at Bath, Mr. Laurence Holland (President) in the chair, Mr. Ivon Graham, M.A., and Mr. F. Lawrence submitted a Paper entitled "The Collection and Analysis of Air-Borne Dust during the Driving of Hard Heading."

The following notes are from the discussion:

Professor A. M. Bryan, discussing the instruments used for collecting dust samples, said he had found that the konimeter was of no use where there were high concentrations. Owing to the very transient nature of the clouds, it was impossible to get an average sample of a very large number of samples. He had used anthracene and napthalene filters very successfully, but it was important that they should be used when fairly fresh, within a few hours after they were made up, because after a day or two they had deteriorated until they were of no use at all. He asked for the authors' opinion with regard to such filters. In one or two cases the dust near the coal face seemed to be stratified, there being various layers each consisting of particles of different size. The samples taken in the general airway gave a fairly good result, but in places where operations were being conducted, the samples varied according to the positions of the collecting tubes. As to the size of particles in suspension, samples were taken by konimeter and by anthracene and naphthalene filters, and 85 or 90 per cent. of the dust in suspension in the samples taken from the airway were of a size less than 5 microns. That was a very different result from that of the authors. Quartz was difficult to reduce to the very fine sizes, and that would affect the amount in suspension, of course.

Mr. F. L. Booth asked for a definition of the term "hard heading," and whether a "hard heading" was a heading in shale only.

Dr. W. Cullen said he had recently returned from South Africa, and had been informed by the Medical Bureau on the Rand that since they began to take certain steps, twelve years ago, no fresh cases of silicosis had arisen in the Rand gold mines. That was a remarkable statement, bearing in mind that thousands of men had died from the disease in the past. The protective measures taken were mainly to drill wet, to blast on one shift, to leave the mine empty during the night shift so that there was dilution by fresh air and all the dust was removed, and to insist that no man was allowed to enter into mining in the Rand mines unless he conformed to certain physical measurements and unless his family history showed no trace of tuberculosis. A great many other minor requirements were also insisted upon, but the four requirements indicated were the essentials. Whilst he appreciated that such precautions interfered with the liberty of the subject, he suggested that we should experience very little trouble due to silicosis in any kind of mine in this country if similar precautions were taken, particularly if we insisted that those entering the mining industry should conform to certain requirements in regard to their physical condition.

The authors intimated that they would reply to the discussion in writing.

### International Association for Testing Materials

The second international congress of this Association will be held in London from April 19 to 24, 1937. The Executive Committee of the Congress Organising Committee is composed as follows:—Sir Frank Smith, K.C.B., C.B.E. (Chairman), Sir William Larke, K.B.E. (Vice-Chairman), Sir Harold Carpenter, F.R.S., Sir Alexander Gibb, F.R.S., Dr. H. J. Gough, F.R.S., Sir Nigel Gresley, C.B.E., Sir Clement Hindley, K.C.I.E., and Mr. K. Headlam-Morley (Honorary Secretary). Sir William Bragg, O.M., K.B.E., President of the Royal Society and Director of the Royal Institution of Great Britain, has consented to be President of the London Congress. Participation in the Congress will be open to all interested in the study of materials and their testing, on payment of the membership fee. The offices of the Congress are at 28, Victoria Street, London, S.W., and full particulars can be obtained from the Secretary.

# Correspondence on Conference Papers

## MR. HUDSON'S PAPER ON SANDS

**From Mr. J. Dearden** (*Works Metallurgist, St. Rollox, L.M.S.*)

Perhaps the author would be good enough to enlighten us on the following questions:—

(1) Which is the better method for determining whether the proportion of coal dust in the sand circulating through a continuous sand-mixing plant is correct—loss on ignition or volume of gas evolved? Also, at what control figure should the coal dust be maintained for a uniform green sand?

(2) The use of sawdust for reducing expansion in dry sand is recommended in the Paper. Does this also apply to green sand, or is coal dust considered sufficient?

(3) Is fireclay regarded as being a satisfactory artificial bond to use for an iron moulding sand?

### Mr. Hudson's Reply

(1) The more practical method for determining the proportion of coal dust in the sand circulating through a continuous sand mixing plant is by loss on ignition. The control figure to be maintained will be principally dependent upon the permeability of the sand. In his practice he maintained a loss on ignition of approximately 9.5 per cent. with a green permeability number of 80 to 100. This gives very satisfactory results for general engineering castings. For ornamental castings or stove-plate work it is customary to use higher coal dust additions than this, together with lower permeability figures, when casting section permits.

(2) The observations in connection with sawdust for reducing expansion also definitely apply to green sand. In the production of many castings coal dust additions to green sand will produce satisfactory results, but for castings of certain design, particularly those mentioned in the Paper, it may be necessary to obtain the maximum reduction in expansion, in which case sawdust is recommended. The use of coal dust or sawdust will have to be determined by experience.

(3) It is not considered that fireclay is a satisfactory artificial bond to use for iron-moulding sand. Bentonite is to be preferred, as this gives a better bond distribution and is composed of practically 100 per cent. clay. On the other hand, the average fireclay contains only about 30 per cent. of effective bonding material. Under certain circumstances, fireclay could be used when only small bond additions are required. For example, it is personal practice to use Bentonite for bonding purposes in connection with the production of dry sand. In this connection, from ¾ to 1 per cent. is added. If the same practice were adopted for green sand production, it has been ascertained that it would be necessary to add only 0.125 per cent. of Bentonite to each batch, which, in personal opinion, is too small a quantity to permit an even distribution being obtained. In this latter case, recourse would be had to a bonded natural moulding sand or fireclay, and a correspondingly greater amount would be added in order to obtain an even distribution throughout the batch. The whole question raised also will depend upon the efficiency or otherwise of the mixing machines available.

**From Mr. J. Longden** (*Clydebank*)

Mr. Hudson has placed foundrymen in his debt by the presentation of valuable data upon the behaviour of sand in high temperature conditions. At the same time, he seems to attempt to reach certain general conclusions, of a practical character, which can hardly be substantiated by the data presented. "It is contended," he says, "that the cause of surface scabs or buckles is due to the combined effects of expansion and increase of sand strength on heating, and any factor reducing either property will tend to eliminate the trouble." The proof offered is the behaviour of a number of dry-sand cores with or without an admixture of coal dust or sawdust. He does not state whether all other conditions are equal; *i.e.*, whether all the cores were rammed by the same man, the venting was adequate and standard throughout, whether the moulds into which the cores were placed were green or dry, whether all the moulds stood for the same length of time before casting and whether in all cases care was taken, in pouring, not to pour straight down the runner but into a part of the basin away from the down-gate. Any variation in these things would affect the results.

In any case, his conclusion is too wide. Whilst it may be true that the high degree of expansion and strength of certain sand mixtures at high temperatures may conduce to scabs, it is quite fallacious to assume that the factors named are totally or even mainly to blame. Scabs are various and may be found writ large in green sand, where coal dust is an ever present factor. Where the act of scabbing can be watched visually (as when casting open-sand plates, etc.) it is always associated with an evolution of gas, *i.e.*, bubbling. Many kinds of scab can be eliminated by intelligent venting. Like patriotism, permeability is not enough. When a mould is filling with molten metal, gases are evolved very rapidly, and unless exit-conductor-channels (vents) are provided in sufficient quantity the gas pressure rises very quickly immediately behind the mould face, resulting in a detachment of part of that face—a scab.

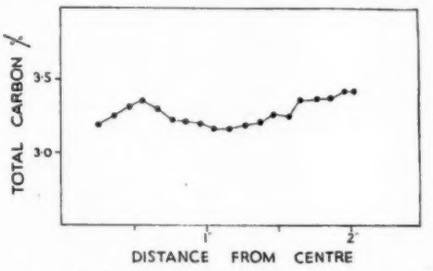



Fig. A.—Carbon Segregation from Centre to Edge of 4.2-in. dia. Vertically-Cast Test Bar in Grey Cast Iron.

Other scabs may appear where the rammer has been used too near the pattern, on a gagger placed too close to the face or too heavily claywashed, or in any part of a drysand mould insufficiently dried. Buckles may appear under bars in the top-part of a green sand plate rammed on the jar-ramming machine. Here this part of the mould is softer than the rest. Scabs here can be eliminated by bringing up the hardness of the mould in the region of the bars to equal the rest. The fact that the same kind of thing can happen in the case of plates made in aluminium alloy and in which the moulds are hand rammed shows that the problem, in essence, is not bound up necessarily with high temperature conditions. I seriously doubt, therefore, if Mr. Hudson has found the nigger in the wood pile.

Finally, whilst one can agree that a blacking wash should preferably have a similar coefficient of expansion to that of the sand upon which it is used, why does Mr. Hudson insist that it should be equally permeable? He appears to suggest that mould gases should be exhausted into the mould cavity. This is fatal to the production of sound castings. In all cases, provision should be made for the exhaustion of mould or core gases in a direction away from the mould face, through the body of the mould and into the open air. To the writer, at any rate, the need for permeability in a blackwash does not appear.

## DR. NORBURY AND MR. MORGAN'S PAPER ON THE FRACTURE OF CAST IRON

**From Dr. J. T. MacKenzie** (*Metallurgist, American Cast Iron Pipe Co., Birmingham, Ala.*)

In regard to Fig. 1, the segregation of carbon in the pig is a peculiar phenomenon and it is difficult to believe that it is all explainable on the basis of eutectic composition. Of course, it is true that with a hyper-eutectic iron such as shown in Pig A, the tendency would be for kish to segregate to the top. But this does not explain the segregation of a like percentage in the C Pig which on the basis of an average composition would be distinctly hypo-eutectic.

It is quite well established that hot iron loses carbon, as any perusal of the high-temperature work will immediately make apparent. Practically no one has been able to superheat cast iron without producing a lower carbon iron at the same time and a good deal of the speculation on this superheating has been unavoidably mixed up with this phenomenon. It is quite difficult also to check carbons between a thin section and a thick section poured out of the same ladle at the same temperature. Whether this is a difficulty of getting the coarse graphite into the combustion boat or whether it is actually some phenomenon connected with the oxidation of carbon during the solidification process has always been questionable from a personal point of view.

The eutectic lines shown in Fig. 3 (and it is presumed also in Figs. 2 and 4) do not take into account the phosphorus content. If the usual rule of 0.3 per cent. phosphorus were applied to this figure it would be found that the eutectic line will curve sharply to the bottom and practically bisect all three lines. The eutectic with 2 per cent. silicon and 0.5 per cent. phosphorus instead of being 3.80 as shown would be at 3.65, and with 1.5 per cent. phosphorus would be 3.35. This rule has been checked personally in centrifugal castings on phosphorus from 0.01 to 2 per cent., and it is certain that it is of universal applicability, as the centrifugal casting process is the best index of the eutectic available.

Considering the titanium-treated iron in Table II, it will be observed that D is very close to the eutectic, being only 3 or 4 points above, quite within the limits of analytical error, whereas C is 12 or 13 points above. Normally, quite a sharp break in strength is found at the eutectic. It is of interest to query if this should not be held responsible for the increased strength instead of the titanium treatment, especially in view of Dr. Norbury's statement at the end of the first paragraph in the middle column of page 455 that "The metal must also be below the eutectic composition for the graphite to be fine." The example in Table I seems a very good example of difference in strength with the same analysis, but the writer is certainly not impressed by the authors' example in Table II.

### Authors' Reply

We find Dr. MacKenzie's contribution very much to the point, and agree with practically all he says. As he points out, Pig C in Fig. 1 is hypo-eutectic in composition, but the carbon analyses show that the carbon has floated up even in this case. Carbon can, however, segretate from other causes, as shown in the accompanying Fig. A, which shows variation of carbon content from edge to centre of a vertically cast test bar. This type of segregation may also be occurring to a certain extent in the pigs shown in Fig. 1, but the main carbon segregation in these pigs appears to be due to flotation. We have observed that there is usually a certain amount of carbon burnt out of the surface of a casting, and suggest that this is due to the action of steam during the cooling of the casting in the mould. More carbon is burnt out in the case of more slowly cooled heavy castings.

With regard to the effect of phosphorus on the eutectic composition, it is briefly stated in the Paper that "phosphorus has a very similar

effect to silicon in reducing the solubility of carbon," and the phosphorus contents of the pigs are given in Fig. 3, but Dr. MacKenzie's observations are extremely useful, as is his figure of 0.3 per cent. which had been obtained from his personal observations. While the authors agree with his observations regarding Table II, they can assure him that they have obtained just the same sort of differences in graphite size and strength on irons further removed from the eutectic composition, although, as stated, the differences in strength become progressively less as the composition becomes further removed from the eutectic composition.

The authors are presenting a Paper in September to the Iron and Steel Institute, entitled "The Effect of Non-Metallic Inclusions on the Graphite Size of Grey Cast Iron," which deals more fully with the subject. They were very interested in some of the round-table discussions the American Foundrymen's Association have been having recently on the qualities of pig-iron, and if Dr. MacKenzie could refer them to any further discussions and Papers of this sort, they would be very interested to read them.

**From Mr. S. E. Dawson** (*Stanton Ironworks*)

In introducing this subject, so fundamentally important to the foundry industry, the authors have indicated the function of carbon and silicon in relation to the eutectic composition and temperature. In practice, however, fractures may vary irrespective of these factors, and a No. 3 iron be produced with a lower silicon than a No. 4, even for similar carbons. Does not this suggest other influences than eutectic balance of composition? For example, the effect of $CO_2$ in the presence of Ti, referred to in the Paper, suggests that the composition of the gases in the furnace and in contact with the metal, might have some bearing on the matter.

Also Boegehold, investigating the same problem, and examining the pig-iron from seven blast furnaces, found that the quality of coke had a large effect on the properties and fracture of the iron, and stressed the importance of the combustibility or maximum burning rate of the coke in this connection, a factor which may not be unconnected with the composition of the gases in the furnace. He further found that such different properties were also present in the cast metal from these pig-irons remelted under identical conditions in the cupola. This was especially observed with regard to hardness and fluidity, and the dilatometer test curves showed the same form and characteristics for each pig-iron and the remelt therefrom. Also, he showed that the effect of moisture in the blast increased the combined carbon and chill progressively for equal compositions.

The investigations of W. E. Jominy on about a hundred pig-iron casts, using two extremes of fuel, namely, charcoal and coke, are worth noting. A considerable difference in structure and fracture was observed in the two series, the graphite in particular being smaller and better distributed in the charcoal pig-iron. On remelting twice over in an electric furnace, under conditions to preserve original compositions, the first remelt showed the charcoal irons to be 20 per cent. stronger in tensile and transverse strength than the coke-melted pig-irons, and this same difference persisted through the second remelt.

Other factors influencing graphite size and fracture may include the so-called "silicate slime" or colloidal silicates, the elimination of which contributes to the improvement in structure which may be so obtained.

These points, amongst others, were referred to in some details by the writer in a Paper given before the East Midlands Branch in October last, and the subject is of such importance that the suggestion then made of a joint investigation by all interests concerned might very well be considered.

## Top-Charged Electric Furnaces

### WIDER USE IN AMERICA

An article in a recent issue of "Steel" points out that the top-charging type of electric furnace was originally patented in 1925, but it is only since 1932 that they have been used to any considerable extent.

The advantages claimed for this type of design not only include the wider use of bulky remelting scrap, many sizes of which cannot be charged through a side-door type electric steel furnace, but a substantial saving to the operator in charging time and labour, power, electrode and refractory costs. These advantages, all inherent in the top-charging furnace's rapid and efficient operation, have led to several recent installations, up to 20 tons capacity, which are meeting with satisfaction in operation.

The main difference in the newer top-charging furnace is that the roof operates in a horizontal plane instead of tilting. It is claimed that strains such as are set up in the tilting-roof type are avoided. The roof-lift-swing-aside movement is made by a powerful ram from the stationary cylinder, the ram having a tapered and keyed head. Oil pressure for this movement usually is furnished by a motor-driven pressure pump, although hydraulic pressure available in many large steel mills also may be used. In the case of oil pressure, however, this is drawn from its associate reservoir tank for operating the heavy double anchor lift and swing-aside cylinder. This mechanism is protected properly by sequence movement interlocks. The heavy roof-lifting cylinder is stationary and separate from the furnace shell. The aforementioned ram moving from the stationary cylinder and effecting the roof-lift movement is integral with a swinging cam roller and operates as follows:

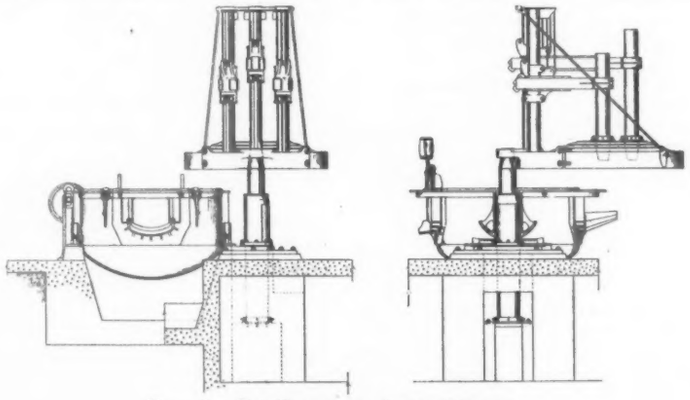


Fig. 1.—Top-Charging Arrangements.

As soon as the vertical lift of the furnace roof has been made, the cam mechanism automatically begins to impart a smooth rotating action to the roof superstructure assembly. The use of heavy roller bearings has been made for the piston head of the ram to pivot on. At the time oil pressure is applied in the cylinder directly beneath the piston head, the lift ram is raised quickly so as to engage the match-machined receiving socket in the steel-column eye casting. Suitable auxiliary guide parts, which will ensure the necessary rigidity for swinging clear of the furnace after slight lifting, are employed as the ram head enters its eye socket.

A plant where the top-charging-type furnace has been installed has made interesting studies on operating costs. This concern has found that the average three-year cost of basic refractories was about 30 per cent. less than the fixed-roof furnace's refractory cost; even though at first it was felt that the swing-aside movement would involve serious refractory difficulties by tearing of the seals between the roof and sides on a hot furnace each time the roof was moved. This same concern tabulated electrode consumption over a three-year period, also in comparison with an adjoining fixed-roof furnace of the same shell diameter and charging with the same materials, to find that electrode consumption was 14 per cent. lower on the top-charging furnace.

## Petroleum (Transfer of Licences) Act, 1936

Having regard to the increasing use of petrol and similar spirits, it has been thought that a short explanation of this new Act may be useful. By the Petroleum (Consolidation) Act, 1928, if petroleum-spirit (meaning petroleum which gives off an inflammable vapour at a temperature of less than 73 deg. Fah.) is kept in a total quantity of more than three gallons, a licence is required for its storage. This applies whether the spirit be kept for sale or for private use, except when such purpose is for use in motor vehicles, boats or aircraft, where the limiting quantity is 60 gallons (a figure which includes any kept in fuel tanks of machines). To keep motor petrol without a licence, certain special conditions contained in Regulations must be observed; if a licence be obtained, then, of course, these special conditions do not apply. The fees chargeable for a licence are as follow: Up to 100 gallons, 5s.; over 100 and up to 500 gallons, 10s.; over 500 and up to 1,000 gallons, 15s.; over 1,000 and up to 5,000 gallons, £1; over 5,000 and up to 10,000 gallons, £2; over 10,000 and up to 20,000 gallons, £3; over 20,000 and up to 50,000 gallons, £4; over 50,000 gallons, £5.

The reason for this new Act, however, is that it has been found that there has been no power in the 1928 Act to make transfers of licences where there has been a change in occupancy or business ownership, and where such have been made, they were illegal. To meet the legal requirement, a new licence with all the accompanying procedure attached to it and extra expense was necessary. Therefore, this new Act now makes clear that a transfer of a licence can be effected, either by endorsement of the licence or otherwise, the transferee then being put in exactly the same place as was the former holder respecting the licence, that person ceasing to have any authority under the licence. Moreover, this legal rule will operate both retrospectively and currently, and any transfers already made will thus be made legal. From July 14, 1936, a transfer fee of only 2s. 6d. will be charged for the transfer of any licence. Licences are obtained from the local council, from the Common Council as respects the City of London, and, if not in the City, but in the County of London, the County Council; in some cases the Home Secretary may function.

# Dimensional Tolerances for Castings (With Particular Reference to Malleable Cast Iron)

## By the Sub-Committee of the Technical Committee on Malleable Cast Iron

(*Concluded from page* 105.)

### Extract from Blackheart Data Illustrating Inaccuracies Mentioned Above

In most cases six castings from each pattern were taken and measured before and after annealing. They are all production jobs, and are proving acceptable to the customers. Cored dimensions are indicated by an asterisk.

Col. A, in Table II, is pattern dimension.

Col. B is maximum variation in hard castings dimensions.

Col. C is maximum hard contraction from pattern.

Col. D is maximum variation in soft castings dimensions.

Col. E is maximum soft contraction from pattern.

On examination of the data in Table II, two facts will at once become apparent:—(*a*) The amount of final contraction shown by the annealed casting varies considerably. This is due partly to variations in hard contraction, and partly to variations in the subsequent expansion during annealing; and (*b*) the amount of variation between different castings produced from the same pattern will be found to have changed considerably after annealing. In the majority of cases the variation between annealed castings is greater than it was in the case of the identical castings, before annealing. This is clearly shown by comparing columns B and D.

A few examples of outstanding variations are set out below:—

*Example* 3.—12$\frac{31}{32}$ in. dimension. Variation between castings before annealing was $\frac{1}{32}$ in. after annealing was $\frac{7}{64}$ in.

*Example* 2.—6$\frac{7}{16}$ in. dimension. Variation before annealing was nil, but after annealing was $\frac{5}{64}$ in. (Note.—This represents a difference of approximately $\frac{1}{8}$ in. per ft.)

*Examples* 1 *and* 4.—Final annealed contraction on several dimensions varies considerably. Maximum contraction shown is approximately $\frac{13}{64}$ in. per ft., and minimum is approximately $\frac{1}{32}$ in. per ft.

Some further data were taken on ring castings shown on Tables III and IV relating to Series 1 and Series 2. Three different sizes of ring pattern of the same design were moulded (Series 1). The patterns were then thickened up and a further set of castings were moulded (Series 2). Both series were then cast from one ladle of metal. After careful measurement, all the castings were annealed in close proximity and under identical conditions. Finally, the castings were again carefully measured and the average contraction of the three diameters was calculated in each case.

The increasing amount of contraction exhibited by the larger diameter rings is of some interest, and it should also be noted that the heavier type (Series 2) exhibited a smaller range of variation. While not intended to prove any fixed relation between contraction and size or section, these figures do serve to indicate how size and section can influence dimensional changes from the pattern size.

### Practical Tolerances for Malleable Cast Iron

Any attempt to define tolerances acceptable to both founder and consumer is fraught with considerable difficulty. It has already been shown that castings can be produced which show comparatively small individual variations, but which may seriously digress from the contraction rule. Economic considerations are bound to limit the amount of experimental work done on any particular pattern, according to the quantity of castings to be produced and the equipment which is available.

It was felt, therefore, that although certain tolerances may be laid down for what might be termed "repetition" work, yet considerably wider tolerances should be allowed for small quantity orders, and also on patterns which are supplied by the customer.

Even so, in both repetition and non-repetition classes, there are bound to be cases where special circumstances or peculiarities of design will result in exceptional amounts of variation from the pattern size. It is felt, however, that it would be impracticable to attempt to cover every possible variable, and that such cases, when they occur, must be subject to special consideration.

After very careful consideration of the whole subject, it is suggested that, except in special cases, the following are reasonable tolerances to cover the majority of variables:—

*Tolerances on Dimensions of Malleable Castings.*

| Dimensional range. | Repetition or "mounted" patterns. | Non-repetition and "loose" patterns. |
|---|---|---|
| Below 4 in. .. | + or − $\frac{1}{32}$ in. on dimension. | + or − $\frac{3}{64}$ in. on dimension. |
| 4 in. to 8 in. .. | + or − $\frac{3}{64}$ in. on dimension. | + or − $\frac{1}{16}$ in. on dimension. |
| Over 8 in. .. | + or − $\frac{1}{16}$ in. per ft. | + or − $\frac{3}{32}$ in. per ft. |

### Dimensional Tolerances on Steel Castings

*(From Data submitted by Steel Castings Sub-Committee.)*

Considerable variation in contraction is experienced in the production of steel castings, due mainly to the following factors:—

(*a*) *Section of Casting.*—Castings of light and reasonably uniform section (say from $\frac{1}{4}$ to $\frac{1}{2}$ in. section) will usually show a net contraction from pattern size of 0.25 to 0.27 in. per ft. Heavier sectioned castings with a metal section of 2 in. or over will, under the same production conditions, show a net contraction from pattern size of as low as 0.20 in. per ft.

*Note.*—In each case, no other variables are taken into account, and the above figures relate to the influence of section alone.

(*b*) *Hindered Contraction in Mould.*—Castings are frequently produced in which the design is such as to hinder the contraction of the casting in the mould, for example, heavy cored work, or frame castings with large projecting feet or brackets. In such cases the net contraction from pattern size may be as low as 0.12 in. per ft. This would give rise to very considerable discrepancies in size, especially on large castings.

(*c*) *Scaling Allowance.*—A scaling allowance of $\frac{1}{64}$ to $\frac{1}{32}$ in. is frequently necessary to cover dimensional variation due to heat treatment.

TABLE III.—*Dimensional Changes in in., in Series* 1, *on Light Type of Ring.*

| Item. | Dimension. | Pattern size. | Hard casting. | Contraction. | Annealed casting. | Expansion. | Net contraction. | Average net contraction, in. per ft. |
|---|---|---|---|---|---|---|---|---|
| Small ring .. | A | $5\frac{11}{32}$ | $5\frac{1}{2}$ | $\frac{3}{64}$ | $5\frac{13}{32}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | 0.1237 |
| | B | $3\frac{3}{8}$ | $3\frac{23}{64}$ | $\frac{5}{64}$ | $3\frac{7}{16}$ | $\frac{1}{32}$ | $\frac{3}{64}$ | |
| | C | $4\frac{43}{64}$ | $4\frac{27}{32}$ | $\frac{3}{32}$ | $4\frac{1}{2}$ | $\frac{3}{64}$ | $\frac{3}{64}$ | |
| | D | $\frac{1}{16}$ | $\frac{1}{16}$ | — | $\frac{1}{16}$ | — | — | — |
| Medium ring .. | A | $6\frac{11}{32}$ | $6\frac{15}{64}$ | $\frac{7}{64}$ | $6\frac{9}{32}$ | $\frac{3}{64}$ | $\frac{1}{16}$ | 0.1574 |
| | B | $4\frac{23}{32}$ | $4\frac{25}{64}$ | $\frac{7}{64}$ | $4\frac{27}{64}$ | $\frac{1}{32}$ | $\frac{5}{64}$ | |
| | C | $5\frac{53}{64}$ | $5\frac{9}{16}$ | $\frac{7}{64}$ | $5\frac{19}{32}$ | $\frac{1}{32}$ | $\frac{5}{64}$ | |
| | D | $\frac{1}{16}$ | $\frac{1}{16}$ | — | $\frac{1}{16}$ | — | — | — |
| Large ring .. | A | $8\frac{11}{16}$ | $8\frac{23}{32}$ | $\frac{1}{64}$ | $8\frac{45}{64}$ | $\frac{3}{64}$ | $\frac{1}{32}$ | 0.2004 |
| | B | $6\frac{3}{4}$ | $6\frac{25}{32}$ | $\frac{1}{64}$ | $6\frac{13}{32}$ | $\frac{3}{64}$ | $\frac{1}{32}$ | |
| | C | $7\frac{21}{64}$ | $7\frac{23}{32}$ | $\frac{1}{64}$ | $7\frac{25}{32}$ | $\frac{1}{16}$ | $\frac{3}{64}$ | |
| | D | $\frac{7}{32}$ | $\frac{7}{32}$ | — | $\frac{7}{32}$ | — | — | — |

### Mechanical Factors

A large number of other factors, generally as listed for malleable cast iron, also have a profound influence on dimensional accuracy.

### Practical Tolerances

No comprehensive investigation has yet been undertaken to determine suitable tolerances for steel castings, but the following have been put forward as an indication of the order of accuracy obtainable:—

(*a*) *Jobbing Work.*—± $\frac{1}{32}$ to $\frac{1}{16}$ in. for small castings.
± $\frac{3}{16}$ to $\frac{1}{4}$ in. for large castings.

(*b*) *Repetition or Machine Work.*—± $\frac{1}{64}$ to $\frac{1}{32}$ in. on small sections.
± $\frac{1}{32}$ to $\frac{1}{16}$ in. on machined sections.

### Dimensional Tolerances on Cast Iron

*(From Data submitted by Cast Iron Sub-Committee.)*

(1) The variation in contraction experienced in the production of grey cast iron castings is also dependent on a very wide range of factors. Generally speaking, those variations which are due to mechanical rather than metallurgical causes, are similar to those previously discussed when considering malleable cast iron.

(2) On the other hand, cast irons vary over a very wide range of chemical compositions and physical structures, and the contraction figures directly attributable to metallurgical factors alone can therefore show considerable variation.

(3) Results taken on the Keep's test bar on different grey irons have given net contraction

figures varying from 0.129 to 0.163 in. per ft. Individual results taken with particular irons on the Keep's test bar would appear to indicate that a limit of ± 0.010 on 12 in. is as close a limit as can normally be expected. The data are given in Table V.

Whilst it is appreciated that depth of chill is an important factor influencing results on the Keep's test bar, it must also be remembered that mechanical variations, such as unequal ramming, rapping of pattern, size of runner, etc., are practically non-existent.

The maximum variation in the case of green sand moulds was $\frac{3}{32}$ in. and in the case of the dry sand moulds from + $\frac{1}{64}$ in. to nil.

### Example (2)

Sixteen rail chair castings from the daily production were selected at random and checked for variations on dimensions. (See Table VII.)

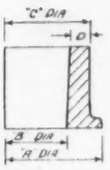
Nevertheless, as it is important to realise, these castings were taken from production and were giving no cause for complaint with the consumer.

The actual tolerances specified by the consumer were:—

± $\frac{1}{32}$ in. on 2$\frac{13}{16}$-in. jaw width.

± $\frac{3}{64}$ in. on width of 4-ft. 8$\frac{1}{2}$-in. road.

Table IV.—*Dimensional Changes in in., in Series 2, in Heavy Ring.*




| Item. | Dimension. | Pattern size. | Hard casting. | Contraction. | Annealed casting. | Expansion. | Net contraction. | Average net contraction in. per ft. |
|---|---|---|---|---|---|---|---|---|
| Small ring .. | A | 5 11/32 | 5 1/4 | 3/32 | 5 9/32 | 1/32 | 1/32 | 0.1374 |
| | B | 3 3/8 | 3 25/64 | 7/64 | 3 13/32 | 1/64 | 1/32 | |
| | C | 4 13/64 | 4 27/64 | 3/32 | 4 11/64 | 1/32 | 1/32 | |
| | D | 5/16 | 5/16 | — | 5/16 | — | — | — |
| Medium ring .. | A | 6 11/32 | 6 7/32 | 1/8 | 6 1/4 | 1/32 | 3/32 | 0.1688 |
| | B | 4 21/32 | 4 17/32 | 1/8 | 4 5/16 | 1/32 | 1/32 | |
| | C | 5 13/64 | 5 21/64 | 3/32 | 5 5/16 | 1/64 | 3/64 | |
| | D | 3/8 | 3/8 | — | 3/8 | — | — | — |
| Large ring .. | A | 8 11/16 | 8 23/64 | 13/64 | 8 9/16 | 5/64 | 1/8 | 0.1844 |
| | B | 6 3/4 | 6 5/8 | 1/16 | 6 3/4 | 1/64 | 1/64 | |
| | C | 7 21/64 | 7 25/32 | 11/64 | 7 27/32 | 1/64 | 7/64 | |
| | D | 3/8 | 3/8 | — | 3/8 | — | — | — |

Note.—The depth of the flange remained correct to pattern size, except the two large rings, which both showed $\frac{1}{64}$-in. gain.

Table V.—*Shrinkage Data for Cast Iron.*

| Test yoke. | Average reading shrinkage on 12 in. | Limits of variation. | |
|---|---|---|---|
| | | Plus. | Minus. |
| 1 | 0.147 | 0.010 | 0.009 |
| 2 | 0.151 | 0.007 | 0.006 |
| 3 | 0.141 | 0.010 | 0.012 |
| 4 | 0.147 | 0.009 | 0.005 |
| 5 | 0.146 | 0.012 | 0.012 |
| 6 | 0.153 | 0.010 | 0.007 |
| 7 | 0.153 | 0.007 | 0.010 |
| 8 | 0.152 | 0.009 | 0.009 |

## Working Tolerances for Cast Iron

Three investigations on dimensional accuracy of jobs in normal production were undertaken as follows:—

### Example (1)

Tests on a number of bracket castings for textile machinery were taken, six castings being measured in each case, and the same quality grey iron being used throughout. (See Table VI.)

It will be seen from Table VI that the variations in length on a dry sand mould are very slight. The green sand mould gave the nearest width to drawing size (viz., 3$\frac{3}{4}$ in.), the higher figures in the dry sand being accounted for by the sag of the mould during handling and drying when lying mould face upwards. This particularly applies to the hand-rammed moulds, which receive more handling before they reached the drying stoves than the jolt ram moulds. The castings observed showed contraction from the original pattern size (21$\frac{1}{16}$ in.), due to all causes (mechanical and metallurgical) by the following amounts:—

*Cast in green sand moulds*: $\frac{1}{8}$ in. to $\frac{3}{16}$ in. contraction from pattern size.

*Cast in dry sand moulds*: $\frac{11}{64}$ in. to $\frac{3}{16}$ in. contraction from pattern size.

Quite apart from the contraction allowed on the pattern, the castings were found to vary individually as follow:—

11-in. hole centre: four castings only were within ±0.010 in.

Maximum variations were +0.055 in. to −0.053 in.

2$\frac{13}{16}$ in. jaw width: eight castings only were within ±0.010 in.

The maximum variations were +0.020 in. to −0.049 in.

Table VII.—*Variations in Grey Castings.*

*Standard Rail Chair. 95 lbs. B.S. Rail Section. Hand rammed on turnover machine, gravity draw. 1 in. round holes at 11 in. centres, stripped with plungers. Jaws formed on pattern with loose slips, two for rail jaw, and one for key.*

The Variations are given in Thousandths of an in.

| Chair number. | Hole centres 11-in. std. drawing. | Jaw width 2$\frac{13}{16}$-in. std. drawing. |
|---|---|---|
| 1 | 11 + 0 | 2 13/16 + 0 |
| 2 | 11 + 10 | 2 13/16 − 2 |
| 3 | 11 + 13 | 2 13/16 − 21 |
| 4 | 11 + 23 | 2 13/16 − 8 |
| 5 | 11 − 53 | 2 13/16 − 49 |
| 6 | 11 − 12 | 2 13/16 + 17 |
| 7 | 11 + 38 | 2 13/16 − 2 |
| 8 | 11 − 3 | 2 13/16 + 17 |
| 9 | 11 + 15 | 2 13/16 + 2 |
| 10 | 11 + 29 | 2 13/16 − 8 |
| 11 | 11 − 38 | 2 13/16 − 2 |
| 12 | 11 − 17 | 2 13/16 − 23 |
| 13 | 11 − 3 | 2 13/16 − 9 |
| 14 | 11 − 14 | 2 13/16 + 20 |
| 15 | 11 + 1 | 2 13/16 + 17 |
| 16 | 11 + 55 | 2 13/16 + 20 |

Hole centres max. + variation + 55 } = Extremes of 108
" " " − " − 53 }

Jaw width max. + variation + 20 } = Extremes of 69.
" " " − " − 49 }

In terms of inches per foot, these figures represent extremes in size between the largest and smallest castings of:—

0.118 in. per ft. on hole centres.

0.210 in. per ft. on jaw width.

(This tolerance affects the bolt centres on which measurements were taken.)

### Example (3)

Tests for dimensional accuracy were taken on numbers of drum type castings in regular production. Some four or five different methods of gating were experimented with, in the endeavour to obtain maximum accuracy. The method finally selected for works production yielded the following data:—

(A) *Hand Rammed.*—Maximum contraction on 11.784 in. dia. = 0.160 in.

Minimum contraction on 11.784 in. dia. = 0.102 in.

Eccentricity varied from 0.020 in. to 0.045 in.

(B) *Machine Rammed.*—Maximum contraction on 10.621 in. dia. = 0.157 in.

Minimum contraction on 10.621 in. dia. = 0.112 in.

Eccentricity varied from 0.020 in. to 0.060 in.

In the light of the above investigations, it would appear more latitude on dimensional accuracy is necessary than is generally appreciated.

## Non-Ferrous Metals

*(From Data compiled by the Non-Ferrous Castings Sub-Committee.)*

Since the term "non-ferrous" covers an extremely wide range of metals in which castings are produced, any considerations on dimensional tolerances must be on a very general footing. As with the other metals previously discussed, the dimensions of castings produced from any given pattern will depend on three primary factors, viz.:—

(1) The amount of contraction normally exhibited by the particular metal being worked.

(2) Hindered contraction (or in some cases expansion) due to restriction in the mould, or to the size-mass or design of the particular casting to be produced. This also includes variables attributable to runner and feeder location and the use of chills.

(3) Variables introduced in moulding, *i.e.*, variation of mould size from pattern size.

Since the many alloys in use have widely differing physical properties, the relative importance of any one factor will vary according to the alloy being worked. For example, certain alloys will exhibit much greater strength and rigidity at elevated temperatures, and will therefore not be so susceptible to dimensional variation due to restriction offered by the mould during the cooling period.

Table VI.—*Dimensional Variations in in., on Grey Iron Bracket Castings.*

| Method of moulding. | Pattern size. (Standard rule.) | Length along joint. | | | Width across joint. | | |
|---|---|---|---|---|---|---|---|
| | | Average. | Variation. | | Average. | Variation. | |
| | | | Plus. | Minus. | | Plus. | Minus. |
| Green sand. Hand ram on turnover machine | 21 1/16 | 20 31/32 | 1/32 | 1/32 | 3 31/32 | Nil. | 1/64* |
| Dry sand. Hand ram on turnover machine .. | 21 1/16 | 20 63/64 | 1/64 | Nil. | 3 63/64 | 1/64 | 3/64 |
| Dry sand. Jolt ram on turnover machine .. | 21 1/16 | 20 63/64 | 1/64 | Nil. | 3 15/16 | Nil. | Nil. |

* On one sample only

FOR STRONG CASTINGS WHICH MACHINE PERFECTLY

WHY WORKINGTON IRONS EXCEL . . .

POINT No. 1

In our own mines at Beckermet, whence the ores for Workington Irons are drawn.

WE MINE OUR OWN ORES

. . . the rich pure West Cumberland ores

THE UNITED STEEL COMPANIES LTD

Workington West Coast Hematite Pig Irons owe their "personality" to the materials from which they are made. We are fortunate in possessing our own mines, producing pure Cumberland ore, uniformly low in phosphorus and sulphur. We also obtain coal and coke from our own pits and coke ovens, and limestone from our own quarries.

Thus we have a primary control over all raw materials which go to make "Workington Irons"—a valuable asset to the foundryman from the point of uniform composition.

WORKINGTON IRON AND STEEL COMPANY, WORKINGTON, CUMBERLAND

Branch of The United Steel Companies Limited

WORKINGTON West Coast Hematite PIG IRONS

W21

Examples of contraction (determined on round bars cast in green sand between yokes) are given below for a few of the commonly cast alloys:—

Aluminium casting alloys: $\frac{1}{8}$ in. per ft.
Aluminium silicon alloys: $\frac{1}{16}$ in. per ft.
Aluminium and manganese bronzes: $\frac{3}{16}$ in. per ft.
Mond metal: $\frac{1}{4}$ in. per ft.
Yellow brass and German silver: $\frac{3}{16}$ in. per ft.
Tin-base white metal: $\frac{1}{16}$ in. per ft.
Lead-base white metal: $\frac{1}{16}$ in. per ft.
Phosphor-bronze: $\frac{3}{16}$ in. per ft.

It should be realised, however, that, so far as foundry practice is concerned, these are purely empirical figures, and will vary greatly with the design of the casting and with the production technique adopted.

The varying allowances made in a particular foundry when producing phosphor-bronze castings are cited below as an example:—

(1) Normal sand-cast work up to about 2 ft. dia.: $\frac{3}{16}$ in. per ft.

(2) Wheels of about 5 ft. or 6 ft. dia.: $\frac{1}{2}$ in. per ft.

(3) Wheels with arms 10 ft. to 14 ft.: $\frac{1}{64}$ in. per ft.

(4) Centrifugally-cast wheels, say 4½ ft. dia.: $\frac{1}{16}$ in. per ft.

These figures, of course, are probably dependent largely on the particular design of the example given, and cannot be considered as a guide to general practice. They do serve, however, to emphasise the difficulties involved in producing castings which are "accurate to drawing."

### American Investigations on Casting Tolerances

Although none of the work on tolerances, carried out by the Technical Committee of the Institute of British Foundrymen during the last three years, has been previously made public, it is of interest to note that the American Foundrymen's Association also undertook a completely independent investigation during 1935 on this same subject. Some correspondence has since been exchanged between the two Committees concerned, and the Committee is greatly indebted to the American Foundrymen's Association for their kind permission to refer to this work.

It may be of interest to remark at this stage, that whereas in this country the subject has been mainly developed by the malleable section of the industry, in America it was the grey iron section which was mainly interested.

The Grey Iron Division of The American Foundrymen's Association circulated privately in May, 1935, a set of tentative tolerances for grey iron castings, which was intended to serve as a basis for discussion on the subject. The suggested range of tolerances is set out below, and it is of interest to note that the figures suggested by these would appear to indicate that they are producing castings to limits very similar to those indicated by the Institute's investigations. The notes given below the table are also extracted from the A.F.A. circular of the same date.

"The schedule of castings size tolerances listed above is proposed for review and criticism of A.F.A. members interested in the production of jobbing castings. The proposed schedule is intended to apply to *quantity production of jobbing castings* and not to very special cases where extremely close tolerances are required or to the few piece orders where tolerances are not ordinarily specified.

"*Specified Tolerances* (see Table VIII) are critical geometrical relations specially required and fully specified on drawings or specifications. These specified tolerances are to be used as a guide by the designer in identifying his construction media limitations.

"*Note.*—When closer limits are required, special casting practice technique may be employed to attain the desired results on certain types of castings. This exacting dimensional requirement is, however, when found practical to attain, accompanied by an increase in the manufacturing cost.

"*Unspecified Tolerances* (see Table VIII) are to be understood as the limits that bound general satisfactory casting practice expected without special designation on drawing or specification."

In view of the fact that these figures have not yet been published in America, it is desirable that they should not be used as a basis for discussion.

Table VIII.—*A.F.A. Tentative Proposal for Grey Iron Castings Size Tolerances.*

(Notes extracted from A.F.A. circular of May 2, 1935.)

| Dimensional range in in. | Suggested tolerances in in. for cast iron. | |
|---|---|---|
| | Specified tolerances. | Unspecified tolerances. |
| Up to 2 .. .. | + or − $\frac{1}{64}$ | + or − $\frac{1}{32}$ |
| 2 to 4 .. .. | + or − $\frac{1}{32}$ | + or − $\frac{1}{64}$ |
| 4 to 7 .. .. | + or − $\frac{3}{64}$ | + or − $\frac{1}{32}$ |
| 7 to 12 .. .. | + or − $\frac{1}{16}$ | + or − $\frac{3}{64}$ |
| 12 to 24 .. .. | + or − $\frac{3}{32}$ | + or − $\frac{1}{16}$ |
| 24 to 40 .. .. | + or − $\frac{1}{8}$ | + or − $\frac{3}{32}$ |
| 40 to 60 .. .. | + or − $\frac{3}{16}$ | + or − $\frac{1}{8}$ |
| 60 to 100 .. | + or − $\frac{1}{8}$ | + or − $\frac{1}{4}$ |
| 100 up .. .. | + or − $\frac{1}{4}$ | + or − $\frac{1}{8}$ |

### Competitive Position of Castings

Although first impressions on studying the data submitted in this report may tend towards a feeling that dimensional variations on castings are somewhat wide, this is not the case. It should be remembered that a very large tonnage of castings is produced annually which meets very exacting dimensional requirements. If small quantity orders are excepted, then it is usually possible for a foundry to produce castings to any reasonable *specified* tolerance. Most of the founder's present difficulties lie in the fact that reasonable practical tolerances on important dimensions are rarely specified on the drawing, with the result that unimportant dimensions (from the consumer's view-point) may be held within close limits, sometimes at the expense of accuracy on a dimension which is important.

The inclusion of defined limits in a dimensions clause would protect the founder against unreasonable demands and unwarranted rejections, and would safeguard the buyer from undesirable inaccuracies. It would encourage the consumer to seek the help of the founder in obtaining greater precision; it would prevent disagreements and improve the relations between the castings producer and consumer. The attainment of greater accuracy than that specified would in no way be prejudiced; rather would the reverse be the case. It would provide a "yard stick" by which the founder could measure his efficiency, and this would encourage the raising of the standard of precision.

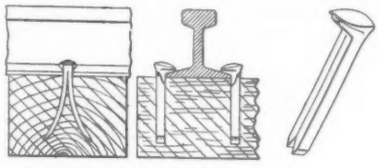
It is hoped that the publication of this Report will serve more purposes than was intended originally. It should be understood that the founder desires to make castings with greater precision and is continually studying ways and means to that end. There is, however, need for greater appreciation by the designer and engineer of the founder's difficulties, and much could be done to produce better and cheaper castings by the proper kind of co-operation. So many castings are badly designed that it is impossible to make them reasonably accurate, whereas the founder's expert knowledge would enable him to suggest alterations which would facilitate the achievement of a high degree of accuracy. Too often the proffered help of the castings manufacturer receives no welcome from the designer. Much assistance would be afforded by the inclusion of more information on drawings. For example, the dimensions where the greatest precision is required, and points where the castings will be jigged could be marked on the drawing and the sequence and nature of machining operations could be stated.

It is realised that the subject is contentious and the tentative proposals here put forward are likely to be received with much criticism. This is what is required, as, before continuing this activity, it is necessary that these recommendations should truly represent the foundry viewpoint and that they should be such as will meet with the approval of the engineering industry. Co-operation of the foundry and engineering trades is therefore most necessary before further progress can be made.

Thanks are expressed to the many organisations, foundries and individuals who assisted in collecting the data for this publication. The list is so great that the names are not mentioned, but special note is made of the American Foundrymen's Association, who so kindly permitted the inclusion of a reference to their unpublished work upon "Grey Iron Castings Size Tolerances."

## New Type of Rail Spike

The accompanying illustration shows a new type of rail spike which consists of a bifurcated stem, the sections of which spread apart when the spike is driven. It is claimed that this spike has pulling resistance of 10,200 lbs., or about four times that of the conventional spike which



New Type of Rail Spike.

does not have the advantages of eight faces and stem-spreading action. The spike is made from bar stock, the chisel points being formed when the stock is cut to length. Each piece is heated to welding temperature and doubled back on itself in hairpin fashion. The loop, or closed end, is formed in a die so that the spike has a head of conventional proportions.—"The Iron Age."

## Patent Specifications Accepted

*The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.*

447,539. Carborundum Company, Limited (Carborundum Company). Production of cast iron.
447,580. Alloy Research Corporation. Iron-chromium alloys.
447,606. Goodyear-Zeppelin Corporation. Processes for improving the physical properties of austenitic-alloy steels.
447,693. Broadbent, H. Cast-iron pipes.
447,704. Victor Chemical Works. Rust-proofing of ferrous articles.
447,932. Sheepbridge Stokes Centrifugal Castings Company, Limited. Manufacture of case-hardened piston rings.
447,975. Linde Air Products Company. Apparatus for removing metal from the surfaces of bodies of ferrous metal.
448,008. Millar, W. J., Howard, J. C., and Electric Resistance Furnace Company, Limited. Heat-treatment of metals.
448,288. Thomas & Company, Limited, R., Kieft, A. W., Mehl, E., and Smetana, O. Production of bright coatings of tin or tin alloys on iron and steel.

# CUMMING'S BLACKINGS
## ARE
# THE BEST

*Extract* from daily report by one of our travellers:—

*January 9th, 1936.*

Mr. C..... said,

"I shall send on to you every time. Since we adopted your Blacking the skin of our castings has improved by 100 per cent. Our customers were the first to notice it."

## NEED WE SAY MORE

All our productions are carefully graded, tested and manufactured.

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**KELVINVALE MILLS, Maryhill, Glasgow, N.W.**
**SUNNYSIDE BLACKING MILLS, Falkirk.**
**WHITTINGTON MILLS, Chesterfield.**
**DEEPFIELDS MILLS, Bilston.**
**STATION CHAMBERS, Middlesbrough.**

# The Week's News in Brief

## Trade Talk

THE EMPLOYEES of Muirhall Foundry, Larbert, held their annual outing to Largs recently.

THE TELEPHONE NUMBER of the Penton Publishing Company, Caxton House, Westminster, of which Mr. V. Delport is manager, has been changed to Whitehall 2743.

BLAIR'S, LIMITED, have been granted permission by the Glasgow Dean of Guild Court to extend their foundry and engineering shops at Woodville Street, Govan, Glasgow.

ANDREW WEIR & COMPANY, LIMITED, London, have placed the order for a 9,000-ton steamer with John Readhead & Sons, Limited, of South Shields. The engines will also be supplied by Readhead's.

AN ORDER for 14 locomotive boilers has been placed by the Bengal-Nagpur Railway Company with Nasmyth, Wilson & Company, Limited, of Patricroft, Manchester. This firm recently completed a similar order for the same railway.

LITHGOWS, LIMITED, Port Glasgow, have received an order from the Hain Steamship Company, Limited, for two large cargo vessels. Diesel engines of the Doxford type will be installed by Barclay, Curle & Company, Limited, Glasgow.

SMITH'S DOCK COMPANY, LIMITED, Middlesbrough, have received an order for a twin-screw vessel from the Trinity House Corporation. The vessel will be fitted with Diesel-electric engines, to be supplied by the English Electric Company, Limited.

SUBJECT TO THE SETTLEMENT of certain points of detail, the Admiralty will place the order for two surveying ships with the Ailsa Shipbuilding Company, Limited, of Troon. The machinery will be constructed by John I. Thornycroft & Company, Limited, of Southampton.

WORK IS NOW PROCEEDING on the new coke-oven plant for the South Durham Iron & Steel Company, Limited, at West Hartlepool. The contractors for this plant are Gibbons Bros., Limited, of Dudley, who have sub-contracted the reinforced concrete work to Holst & Company, Limited, London and Leeds.

HURST NELSON & COMPANY, LIMITED, Motherwell, are to build twenty-five 20-ton hopper grain wagons and 350 medium merchandise wagons; P. & W. Maclellan, Limited, Glasgow, ten 20-ton implement trucks, and R. Y. Pickering & Company, Limited, Wishaw, two thousand 12-ton medium merchandise wagons, for the L.M.S. Railway.

THE MOTOR VESSEL "Eildon" was launched by the Grangemouth Dockyard Company, Limited, last week. It is the first vessel to be built at Grangemouth for six years, and is the first motor-driven collier on the British coast. The propelling machinery, of the Atlas Polar Diesel type, was supplied by Aitchison, Blair, Limited, of Clydebank.

R. A. LISTER & COMPANY, LIMITED, of Dursley, are supplying thirty auto-trucks, which are to convey visitors round the extensive grounds of the Empire Exhibition in Johannesburg this autumn. The company will also have a comprehensive display of their products on the stands of their distributors in South Africa, Stewarts and Lloyds of South Africa, Limited.

THE SOUTH AFRICAN RAILWAYS AND HARBOURS ADMINISTRATION is calling for tenders, to be presented in Johannesburg by October 6, 1936, for the supply of eight 4-ton electrically-driven portal jib cranes, complete with electrical equipment and spares. Firms desirous of offering cranes of United Kingdom manufacture can obtain the further details of this call for tenders upon application to the Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. The reference number T.Y. 30,634 should be quoted.

IN ORDER to cope with the ever-increasing demands for their productions, Daniel Adamson & Company, Limited, Dukinfield, have found it necessary to make considerable additions and extensions to their already extensive premises. As is well known, the firm are manufacturers of steam turbines, turbo-compressors, turbo-generators, shell boilers of all types, and in addition are producers of all classes of riveted and welded vessels, tanks, chimneys, etc. It is understood that the new extensions will be available for production by the end of October.

ACCORDING TO A MESSAGE from Sydney, the Australian Iron & Steel Company, Limited, a subsidiary of the Broken Hill Proprietary Company, Limited, has acquired ground at Port Kembla for the extension of its iron and steel works. Extensions are to be built in the next three years at the cost of £2,000,000, and will include blast-furnace plant and plant for making galvanised sheets, tinplate, wire screens, wire rails, also coke ovens and a works for motor-car bodies. Lysaght's Newcastle Works, Limited, are to erect a new plant at the same place for making galvanised sheets, at a cost of £500,000. The proposal to build aircraft works at Port Kembla and other industrial developments are also under consideration.

THE RESCHITZER IRON AND STEEL WORKS, the principal metallurgical concern in Roumania, report a profit of 644,130,000 lei in 1935, as compared with 490,110,000 lei in 1934, of which 97,860,000 and 57,450,000 lei respectively were absorbed by taxes; depreciation and losses on exchange took 226,610,000 and 155,650,000 lei respectively. The net profit was 74,030,000 lei in 1935, against 55,080,000 lei in 1934, the available balance, after adding the sums brought in, being 87,040,000 and 69,970,000 lei respectively. No dividend has yet been declared for 1935; 6 per cent. was paid in 1934. The gross profit of the Titan, Nadrag, Calan iron and steel works was 312,200,000 lei in 1935, against 213,600,000 lei in 1934, and the net profits 69,870,000 and 59,370,000 lei respectively. The available balances were 87,040,000 and 69,690,000 lei respectively. In 1934 a dividend of 12 per cent. was paid; no dividend for 1935 has yet been paid. (Average current rate of exchange: £1 = 674 lei.)

## Contracts Open

**Bonvilston,** August 25. — Multi-stage centrifugal pump and electric motor direct coupled, capacity 75 galls. per min. against 341-ft. head, with valves, cast-iron pipes and special castings, within specified limits. for the Cardiff Rural District Council. Mr. W. Farrow, engineer, 20, Park Place, Cardiff. (Fee £2 2s., returnable.)

**Cannock,** August 24.—76 yds. of 24 in. dia. and 8 yds. of 12 in. dia. spigot and socket spun-iron pipes, class D, and specials, for the Urban District Council. The Surveyor, Council House, The Green, Cannock.

**Crayford,** October 5.—Four high-compression heavy fuel-oil engines with centrifugal pumps, etc., for the Metropolitan Water Board. The Chief Engineer, Rosebery Avenue, E.C.1. (Fee £2 2s., returnable.)

**Dunmow,** August 29.—Two sets (four pumps) of 3-in. dia. unchokeable centrifugal pumps of the single-bladed impeller type, complete with electric motors and automatic float-controlled switchgear, for the Rural District Council. Tooley & Foster, engineers, Buckhurst Hill, Essex.

## Company Reports

**Warner & Company, Limited.**—Profit for the year amounts to £4,082; brought in, £951; available, £5,033; dividend on preference shares at the rate of 3 per cent. (less tax) for year ended June 30, 1936, £2,075; directors' fees, £383; income tax, £942; depreciation, £1,000; balance forward, £581.

**Broken Hill Proprietary Company, Limited.**—Net profit for year ended May 31 amounted to £850,361, after providing £615,052 for depreciation and £23,305 for debenture interest. During the past year two dividends each of 6¼ per cent. have been paid, against two dividends each of 5 per cent. for 1934-35.

## New Company

*(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)*

**Widnes Foundry & Engineering Company, Limited.**—Capital £1,000 in £1 shares. The objects are to acquire from Thos. W. Ward, Limited, the undertaking and assets of Widnes Foundry (1925), Limited. Solicitors: Broomhead, Wightman & Reed, 14, George Street, Sheffield.

## Personal

MR. A. SUTCLIFFE has changed his address to 40, Roscow Avenue, Breightmet, Bolton, Lancs.

MR. C. H. V. WILSON (Messrs. Wm. Cumming & Company, Limited) has changed his address to 70, Manville Road, Balham, London, S.W.17.

MR. STANLEY W. RAWSON, who for some time has been in charge of the London office of John Brown & Company, Limited, has been elected to a seat on the board of the company.

MR. THOMAS RITCHIE, who heads the delegation of Australian Scots which toured the country, recently visited Falkirk. Mr. Ritchie was born in Carron in 1866 and after a short time in the offices of the Carron Company he was apprenticed to the tinsmith trade with Dobbie Forbes & Company. When 23 years of age he emigrated to Melbourne, where he worked for Sir Robert Gibson. In 1905, with Mr. Tom Anderson, of Falkirk, he started in the foundry business, and to-day the firm of Anderson & Ritchie is known all over South Australia. Mr. Ritchie stated that the light castings industry in Australia had made great strides in recent years, and that there were many prosperous foundries staffed by highly-skilled men. There had been great alterations in foundry practice in the Dominion, and the foundries to-day were as efficient and well equipped as those in Great Britain. Australia was now producing all the pig iron she required and it was of an excellent quality. The foundries were also making and enamelling sufficient baths to supply the home demand without importing any from abroad.

MR. ALLAN G. FOSTER, M.I.Mech.E., has been appointed director and general manager of J. Browett Lindley (1931), Limited, and general manager of the Campbell and Coborn engine departments of Kryn & Lahy (1928), Limited. Mr. Foster's engineering career has been both varied and interesting. He commenced as a pupil at Brown, Marshall & Company's works in Birmingham, continuing with the Birmingham Railway Carriage & Wagon Company, Limited, where he became chief draughtsman and then with Cravens Railway Carriage & Wagon Company, Limited, of Darnall, Sheffield, where he was general manager for a number of years. Subsequently, from 1915 to 1929, Mr. Foster became an executive director of Clayton & Shuttleworth, Limited, and Clayton Wagons, Limited, of Lincoln. Before joining the Letchworth firms with which he is now associated, Mr. Foster was actively engaged in a works re-organisation scheme at the English Electric Company. In addition to this wide experience of the management and production side of heavy engineering firms, he has also travelled on commercial matters to most parts of the world.

### Wills

BLAIR, DAVID ALEXANDER, managing director of Blair's, Limited, iron-founders, Govan, Glasgow ... ... £105,511

## Obituary

MR. ALFRED BALDWIN, of Parkwood House, Keighley, a director of James Baldwin & Company, Limited, brassfounders and engineers, Devonshire Works, Keighley, died last week, aged 67.

THE DEATH OCCURRED, on Wednesday of last week, of Mr. Edgar Martin, an ironfoundry owner, of Prentice Road, Stowmarket. Before establishing himself in business in 1933 he was works manager of the Suffolk Iron Foundry.

MR. FREDERICK RAWE, managing director of A. Bainbridge, Limited, iron and steel merchants, Thornaby-on-Tees, died on August 7. Mr. Rawe had been with A. Bainbridge, Limited, for 35 years, and had been managing director for five years. He was 60 years of age.

PRELIMINARY PREPARATIONS for laying the keel of the new Cunard White Star liner "552," the sister ship of the "Queen Mary," is now in progress in the Clydebank shipyard of Messrs. John Brown & Company, Limited. Additional concrete piles are being driven into the river bed to reinforce the wharf by the side of the fitting-out basin, and the platers' sheds are being enlarged, while new plant is being installed in the engine shops.

# THE "ROCKET" CORE MAKING MACHINES

## HELP to . . .

## REDUCE COSTS AND MAKE SOUND CASTINGS

*for*

## BRITISH

— STEEL FOUNDERS —
GREY IRON FOUNDERS
MALLEABLE FOUNDERS
NON-FERROUS FOUNDERS

*used in the manufacture of—*

Electric Cookers. Gas Cookers. Motor Transport Vehicles. Aeroplanes. Internal Combustion Engines. Cast Iron Bath Fittings. Brass Water Service Fittings. Sluice Valves. Gas Valves. Rain Water Castings. Textile Machinery. Lawn Mowers. Ship Building, etc., and General Engineering Castings.

## FOUNDRY ENGINEERS LIMITED

HALIFAX — YORKS.

Telephone: Halifax 61459. Telegrams: "FEL," Halifax.

# Raw Material Markets

The demand for iron and steel has been quieter recently owing to holiday interruptions. Pressure for deliveries of pig-iron is not quite so insistent, but good tonnages continue to move into consumption. In the steel section of the industry the Government's rearmament programme is responsible for substantial tonnages changing hands, while structural steel is being taken up by home industrial concerns for extension purposes. Recent orders in the shipbuilding industry will ensure a heavy consumption of iron and steel over a long period.

## Pig-Iron

**MIDDLESBROUGH.**—Deliveries of pig-iron in the Cleveland area remain heavy. It is still impossible completely to satisfy consumers' requirements, and fair tonnages of Midlands iron are still being utilised. Scottish works have taken up large quantities since the resumption after their holidays and this has caused increased scrutiny with regard to the distribution of supplies to other users. August is the holiday month in the Cleveland area and many of the consuming works will be idle for varying periods, thus allowing makers to decrease to some extent the arrears of deliveries. The autumn demand will not be easily met. Any day-to-day transactions that are carried through are made on the basis of Cleveland No. 3 G.M.B. at 75s. per ton in the Middlesbrough and Falkirk areas, 77s. on the North-East Coast and 78s. on Clydeside.

The heavy demand from home consumers of East Coast hematite has been supplemented by the receipt of inquiries from the United States for supplies amounting to considerable tonnages. It is still difficult for makers to keep pace with their commitments and August is not likely to show the customary slackness in this respect. Mixed numbers of East Coast hematite are 85s. per ton in the Middlesbrough and North-East Coast zones, 90s. 6d. in Sheffield and 96s. in the Midlands, all these prices being subject to 5s. rebate.

**LANCASHIRE.**—Activity in this area has slackened as a result of holiday interruptions, and deliveries have been on a decreased scale. A revival should not be far away, however, for local foundries have well-filled order-books which must inevitably result in substantial requirements of pig-iron. For delivery in the Lancashire area, offers of Staffordshire and Derbyshire brands of No. 3 foundry are quoted on the basis of 83s. per ton, with Northants at 81s. 6d. and Derbyshire forge iron at from 78s. to 80s. Scottish foundry iron is offered at about 90s., with East Coast hematite at 93s. and West Coast material at 93s. 6d., less rebate, delivered equal to Manchester.

**MIDLANDS.**—There has been a general resumption of work in this area following the holidays, and conditions are very active. The demand for machinery is expanding and is providing large orders for the light and heavy castings makers. The Association's minimum prices, delivered Birmingham and Black Country stations, are unchanged at 77s. 6d. for No. 3 Northants and 80s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, a small sliding-scale rebate being allowed to large consumers. Many users have covered their needs as far ahead as March, 1937. The price of forge pig-iron remains at 5s. per ton below that of No. 3 foundry, and 3s. per ton less if required for use in ironfoundries. General engineers and jobbing founders have heavy requirements of the special-grade irons, the prices of which still remain without control. Medium-phosphorus iron is quoted between 82s. 6d. and 90s., low-phosphorus, including Scottish, between 92s. 6d. and 100s., and refined iron at £6 10s. to £7 15s., delivered this area. Makers of hematite are unwilling to sell beyond December, and, as they mostly have their outputs fully disposed of until the end of the year, there is very little new business being transacted. The controlled prices, delivered Birmingham and Black Country stations, and subject to 5s. rebate to users in the scheme, are £4 17s. for West Coast mixed numbers, £4 16s. East Coast No. 3, and £4 15s. 6d. Welsh mixed numbers; 1s. 6d. per ton extra is charged if deworks in 10-ton lots.

**SCOTLAND.**—Activity in the shipbuilding yards of this area promises to be considerable for many months to come following the placing of orders for a large number of steamers recently. Pig-iron prices are unchanged, the official minimum for No. 3 foundry being 79s. f.o.t. furnaces, with 2s. 6d. per ton extra for No. 1. No. 3 Cleveland is quoted at 75s. f.o.t. Falkirk and 78s. f.o.t. Glasgow, with other English foundry quoted at 1s. 3d. per ton less. It is rumoured that prices for high-phosphorus iron are likely to be altered, but no official statement has been made. Light-castings founders are well employed, while the steelworks are working to capacity and taking heavy deliveries of pig-iron. Prices of steelmaking irons are:—Mixed numbers East Coast, West Coast and Scottish hematite 85s. 6d., less 5s. rebate; basic, British and Indian, 75s., less 5s. rebate, all delivered steelworks here.

## Coke

Users of foundry coke are now in the market for their winter needs, which are being obtained at current prices. Quotations have not been reduced since last winter. For delivery in Birmingham and district, best Durham coke is at 41s. 6d. per ton, and Welsh at 39s. 6d. to 50s. per ton. Supplies of Scottish coke are very scarce.

## Steel

In view of the strong demand for all descriptions of steel, the usual August holidays have been curtailed in a number of producing districts, and the works are operating at capacity, states the official report of the London Iron and Steel Exchange. The requirements of the home trade leave little surplus for export in any department, but recently many of the oversea markets have developed considerable activity. An interesting feature of the situation is an advance in the export prices of the Continental Steel Cartel following the increase in the British steelmakers' quotations for oversea destinations. The demand for semi-finished steel appears to be expanding, and some consumers are displaying nervousness regarding their future supplies. Many of the producing works are behind in deliveries, although the plants manufacturing this class of steel are operating at capacity. In the finished-steel section of the market a slight seasonal relaxation in new business is noticeable in some departments. There is no decline in the quantities passing into consumption, however, and most of the producing works are finding it difficult to meet their customers' requirements.

## Scrap

New business in the Cleveland scrap market has been quiet during the past week. Most users are well supplied with material, a large proportion of which consists of imported metal. Good heavy steel scrap is still quoted at 57s. 6d. per ton. Machinery metal is at 65s. and good heavy foundry cast iron is 62s. 6d. per ton, delivered users' works. In the South Wales market conditions have been quiet, owing to holidays. Heavy steel scrap in furnace sizes is in short supply at 62s. to 63s. Good, clean, heavy mild-steel turnings have only a small demand at 52s. 6d. to 53s. 6d., while mixed wrought-iron and steel scrap for basic furnaces is also in small demand at 58s. to 60s. Heavy cast iron in large pieces and furnace sizes remains at 58s. to 60s., a fair demand being experienced. A limited local sale exists for good cast-iron machinery scrap for foundry use at 62s. to 64s. per ton. A good demand continues to be seen for all descriptions of scrap on the Midlands market. Large supplies are available. Deliveries are also on a good scale in the Scottish market. Heavy steel scrap remains at 57s. 6d. per ton, while basic, or heavy iron and steel scrap mixed, is 5s. per ton less. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is firm around 68s. 6d. to 70s., while heavy ordinary cast-iron scrap, to the same specification, is around 65s. per ton, delivered f.o.t. consumers' works.

## Metals

**Copper.**—Firm conditions have prevailed on this market during the past week. Buying in this country has been only small, but this is not unexpected at this season of the year, when many of the consuming works are closed for holidays. The interruption will be made as short as possible, as most concerns are well supplied with work. Continental users have been in the market for large tonnages recently. In the United States the copper situation is regarded as very encouraging. Sales of copper for export have been reported at 9.60 cents and 9.62 cents per lb., but producers are represented as being unwilling further to advance domestic prices for fear of reducing demand by encouraging the use of substitutes, and also of increasing competition by high-cost producers who are unable to operate at present prices.

Daily market prices :—

*Cash.*—Thursday, £38 2s. 6d. to £38 3s. 9d.; Friday, £38 6s. 3d. to £38 7s. 6d.; Monday, £38 8s. 9d. to £38 11s. 3d.; Tuesday, £38 11s. 3d. to £38 12s. 6d.; Wednesday, £38 7s. 6d. to £38 8s. 9d.

*Three Months.*—Thursday, £38 7s. 6d. to £38 8s. 9d.; Friday, £38 12s. 6d. to £38 13s. 9d.; Monday, £38 13s. 9d. to £38 15s.; Tuesday, £38 16s. 3d. to £38 17s. 6d.; Wednesday, £38 12s. 6d. to £38 15s.

**Tin.**—Demand in this country and on the Continent has declined further, while quieter conditions are reported in the United States. The statistics published last week with regard to the total visible supply were more favourable than had generally been anticipated and caused a temporary firmness in the market. Consumers are unwilling at the present time to enter the market for other than their immediate requirements. The Siamese authorities issued a statement on Saturday intimating that Siam has already accepted renewal of tin restriction, in principle, and asserting that as regards methods of restriction and amount of the quota has gone out of her way to make a big reduction from her original request. M. Van den Broek, one of the two delegates of the International Tin Committee, said that Siam's demands with respect to the fixing of her quota were " ridiculously high," and " in effect no restriction at all." The next meeting of the International Tin Committee has been postponed until September 18.

Metal Exchange quotations were as follow :—

*Cash.*—Thursday, £184 to £184 5s.; Friday, £182 10s. to £183; Monday, £182 5s. to £182 15s.; Tuesday, £185 5s. to £185 10s.; Wednesday, £184 5s. to £184 7s. 6d.

*Three Months.*—Thursday, £180 15s. to £181; Friday, £179 10s. to £179 15s.; Monday, £179 5s. to £179 7s. 6d.; Tuesday, £182 5s. to £182 10s.; Wednesday, £181 2s. 6d. to £181 7s. 6d.

**Spelter.**—Heavy liquidation followed the announcement of a breakdown in the negotiations for the formation of a Zinc Cartel. The news of the setback came as a great surprise to the market, which had been under the impression that the first meeting of the Cartel was in the offing. The whole cause of the situation is unknown, but the trend towards economic self-sufficiency by various countries, which tends to restrict the openings left for some of the erstwhile big producers, is a likely suggestion.

Official quotations were as follow :—

*Ordinary.* — Thursday, £13 10s.; Friday, £13 8s. 9d.; Monday, £13 7s. 6d.; Tuesday, £13 7s. 6d.; Wednesday, £13 7s. 6d.

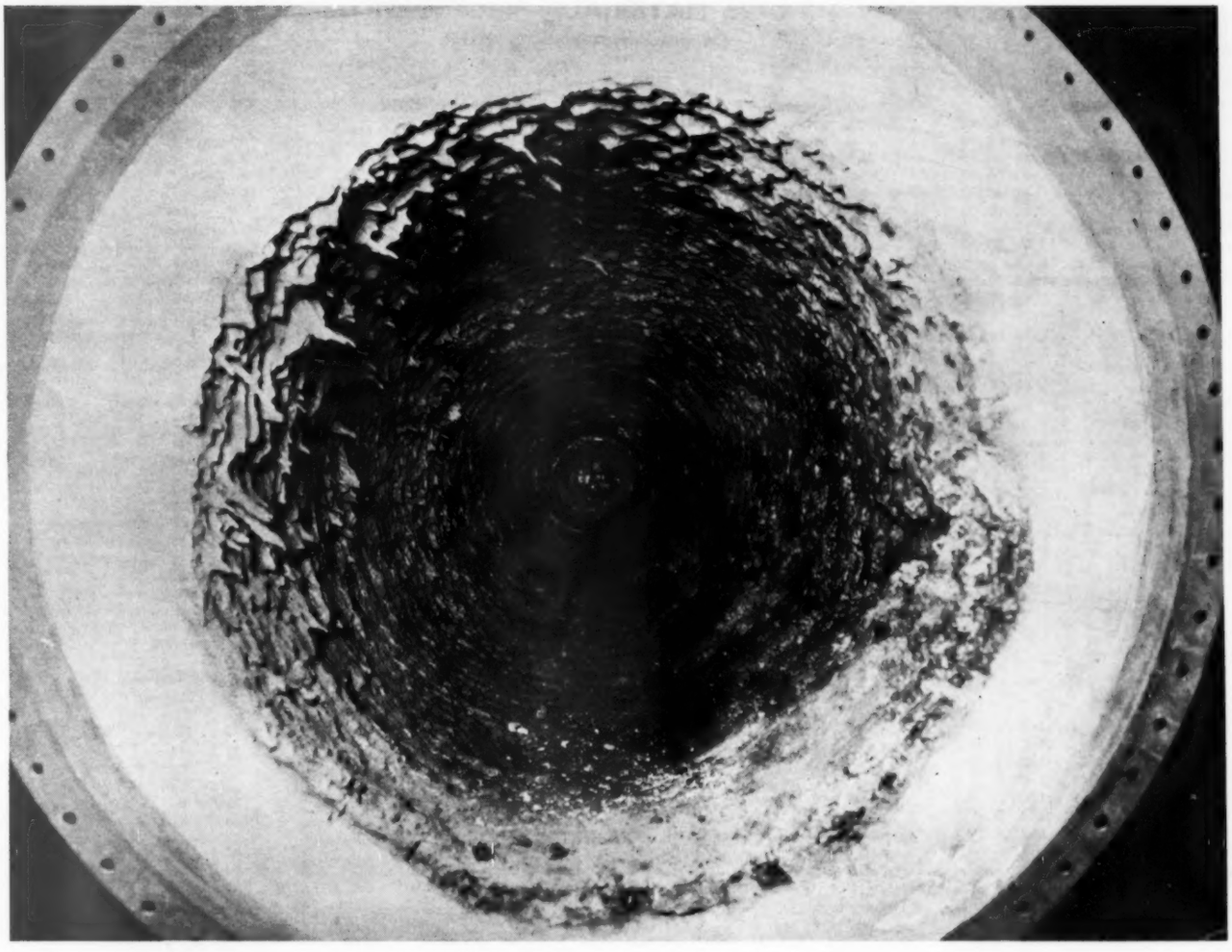
**Lead.**—This market has remained steady, with some fair buying on forward account. According to the quarterly statistics issued by the British Metal Corporation, the consumption of lead expanded in this country during the second quarter of the year from 83,000 tons, the figure for the first three months of the year, to 88,000 tons.

Day-to-day quotations :—

*Soft Foreign (Prompt).*—Thursday, £16 8s. 9d.; Friday, £16 15s.; Monday, £16 17s. 6d.; Tuesday, £16 15s.; Wednesday, £16 12s. 6d.

### Reactions in the Basic O.-H. Furnace

In Report No. 309 of the steelworks committee of the Verein deutscher Eisenhüttenleute, published in the " Archiv für das Eisenhüttenwesen," H. SCHENCK and W. RIESS describe investigations on the chemistry of the basic steelmaking process in which a series of basic open-hearth melts were studied, and the relationships determined between the composition of the slag and the free contents of FeO, MnO, CaO and $SiO_2$, such relationships being governed by the temperature.



# 950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn back evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles.
This photograph is reproduced by courtesy of James Howden and Company (Land) Ltd.

## ALBINO

**ROTARY FURNACE LINING MATERIAL**

***Please write for further particulars to the sole manufacturers:***

**GENERAL REFRACTORIES LIMITED,**
**Genefax House, Sheffield, 10**

Telephone: Sheffield 31113 (6 lines) Telegrams: "Genefax, Sheffield"

MANUFACTURERS OF HEAT RESISTING AND HEAT INSULATING MATERIALS OF EVERY DESCRIPTION

# RAW MATERIALS—PRICE LIST

**(Wednesday, August 12, 1936)**

## COPPER

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 38 | 7 | 6 |
| Three months | 38 | 12 | 6 |
| Electrolytic | 42 | 10 | 0 |
| Tough | 41 | 0 | 0 |
| Best selected | 41 | 10 | 0 |
| Sheets | 70 | 0 | 0 |
| India | 51 | 15 | 0 |
| Wire bars | 43 | 0 | 0 |
| Ingot bars | 43 | 0 | 0 |
| H.C. wire rods | 46 | 10 | 0 |
| Off. av. cash, July | 37 | 5 | 0 1/16 |
| Do., 3 mths., July | 37 | 10 | 10 5/16 |
| Do., Sttlmnt., July | 37 | 5 | 2 1/16 |
| Do., Electro, July | 41 | 8 | 7 1/16 |
| Do., B.S., July | 40 | 19 | 8 3/16 |
| Do., wire bars, July | 41 | 12 | 8 1/16 |
| Solid drawn tubes | | | 10½d. |
| Brazed tubes | | | 10½d. |
| Wire | | | 6½d. |

## BRASS

| | |
|---|---|
| Solid drawn tubes | 9½d. |
| Brazed tubes | 11½d. |
| Rods, drawn | 8½d. |
| Rods, extd. or rlld. | 5d. |
| Sheets to 10 w.g. | 8d. |
| Wire | 7½d. |
| Rolled metal | 7½d. |
| Yellow metal rods | 5d. |
| Do. 4 × 4 Squares | 5½d. |
| Do. 4 × 3 Sheets | 5½d. |

## TIN

| | £ | s. | d. |
|---|---|---|---|
| Standard cash | 184 | 5 | 0 |
| Three months | 181 | 2 | 6 |
| English | 184 | 5 | 0 |
| Bars | 186 | 5 | 0 |
| Straits | 189 | 5 | 0 |
| Australian | 184 | 5 | 0 |
| Eastern | 183 | 5 | 0 |
| Banca | 187 | 5 | 0 |
| Off. av. cash, July | 186 | 4 | 5 1/16 |
| Do., 3 mths., July | 182 | 12 | 0 3/16 |
| Do., Sttlmt., July | 186 | 2 | 9 1/16 |

## SPELTER

| | £ | s. | d. |
|---|---|---|---|
| Ordinary | 13 | 7 | 6 |
| Remelted | 13 | 0 | 0 |
| Hard | 11 | 5 | 0 |
| Electro 99.9 | 15 | 7 | 6 |
| English | 14 | 5 | 0 |
| India | 12 | 5 | 0 |
| Zinc dust | 19 | 10 | 0 |
| Zinc ashes | 4 | 5 | 0 |
| Off. aver., July | 13 | 14 | 0 7/16 |
| Aver. spot, July | 13 | 11 | 6 1/16 |

## LEAD

| | £ | s. | d. |
|---|---|---|---|
| Soft foreign ppt. | 16 | 12 | 6 |
| Empire | 17 | 10 | 0 |
| English | 18 | 15 | 0 |
| Off. average, July | 15 | 18 | 1 4/16 |
| Average spot, July | 15 | 17 | 1 11/16 |

## ALUMINIUM

| | |
|---|---|
| Ingots | £100 to £105 |
| Wire | 1/3 to 1/4 l b |
| Sheet and foil | 1/2 to 1/4 lb. |

## ZINC SHEETS, &c.

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Zinc sheets, English | 24 | 0 | 0 to | 24 | 10 | 0 |
| Do., V.M. ex-whse. | 24 | 0 | 0 to | 24 | 10 | 0 |
| Rods | | | | 25 | 10 | 0 |

## ANTIMONY

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| English | 64 | 10 | 0 to | 65 | 10 | 0 |
| Chinese, ex-whse. | | | | 51 | 0 | 0 |
| Crude, c.i.f. | | | | 24 | 10 | 0 |

## QUICKSILVER

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Quicksilver | 11 | 15 | 0 to | 12 | 5 | 0 |

## FERRO-ALLOYS AND STEEL-MAKING METALS

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Ferro-silicon— | | | | | | |
| 25% | | | | 8 | 17 | 6 |
| 45/50% | 11 | 10 | 0 to | 12 | 15 | 0 |
| 75% | 16 | 12 | 6 to | 17 | 17 | 6 |
| Ferro-vanadium— | | | | | | |
| 35/50% | | | | 12/8 lb. Va. | | |
| Ferro-molybdenum— | | | | | | |
| 70/75% carbon-free | | | | 4/6 lb. Mo. | | |
| Ferro-titanium— | | | | | | |
| 20/25% carbon-free | | | | 9d. lb. | | |
| Ferro-phosphorus, 20/25% | | | | £21 to £22 | | |
| Ferro-tungsten— | | | | | | |
| 80/85% | | | | 3/- lb. | | |
| Tungsten metal powder— | | | | | | |
| 98/99% | | | | 3/1½ lb. | | |
| Ferro-chrome— | | | | | | |
| 2/4% car. | | | | 33 | 0 | 0 |
| 4/6% car. | | | | 21 | 10 | 0 |
| 6/8% car. | | | | 21 | 0 | 0 |
| 8/10% car. | | | | 21 | 0 | 0 |
| Ferro-chrome— | | | | | | |
| Max. 2% car. | | | | 33 | 10 | 0 |
| Max. 1% car. | | | | 36 | 5 | 0 |
| Max. 0.50% car. | | | | 37 | 5 | 0 |
| 70% carbon-free | | | | 9½d. lb. | | |
| Nickel—99.5/100% | | | | £200 to £205 | | |
| "F" nickel shot | | | | £184 | 0 | 0 |
| Ferro-cobalt, 98/99% | | | | 6/3 to 6/9 lb. | | |
| Metallic chromium— | | | | | | |
| 96/98% | | | | 2/5 lb. | | |
| Ferro-manganese— | | | | | | |
| 76/80% loose | £11 | 5 | 0 to | 11 | 15 | 0 |
| 76/80% packed | £12 | 5 | 0 to | 12 | 15 | 0 |
| 76/80% export | (nom.) | £10 | 5 | 0 | | |
| Metallic manganese— | | | | | | |
| 94/96% carbon-free | | | | 1/3 lb. | | |

Per ton unless otherwise stated, basis 2-ton lots.

## HIGH-SPEED TOOL STEEL

| | |
|---|---|
| Finished bars, 14% tungsten | 2s. 0d. |
| Finished bars, 18% tungsten | 2s. 9d. |

Per lb. net, d/d buyers' works.

| | |
|---|---|
| Extras— | |
| Rounds and squares, 3 in. and over | 4d. lb. |
| Rounds and squares, under ½ in. to ¼ in. | 3d. lb. |
| Do., under ¼ in. to 7/16 in. | 1/- lb. |
| Flats, ½ in. × ¼ in. to under 1 in. × ⅜ in. | 3d. lb. |
| Do., under ½ in. × ¼ in. | 1/- lb. |
| Bevels of approved sizes and sections | 6d. lb. |

Bars cut to length, 10% extra.

## SCRAP

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| South Wales— | | | | | | |
| Heavy steel | 3 | 2 | 0 to | 3 | 3 | 0 |
| Mixed iron and steel | 2 | 18 | 0 to | 3 | 0 | 0 |
| Heavy cast iron | 2 | 18 | 0 to | 3 | 0 | 0 |
| Good machinery | 3 | 2 | 0 to | 3 | 4 | 0 |
| Cleveland— | | | | | | |
| Heavy steel | | | | 2 | 17 | 6 |
| Steel turnings | | | | 2 | 0 | 0 |
| Heavy cast iron | 3 | 2 | 6 to | 3 | 5 | 0 |
| Heavy machinery | | | | 3 | 7 | 6 |
| Midlands— | | | | | | |
| Light cast-iron scrap | | | | 2 | 12 | 6 |
| Heavy wrought iron | 3 | 5 | 0 to | 3 | 7 | 6 |
| Steel turnings | | | | 2 | 0 | 0 |
| Scotland— | | | | | | |
| Heavy steel | | | | 2 | 17 | 6 |
| Ordinary cast iron | | | | 3 | 5 | 0 |
| Engineers' turnings | | | | 2 | 2 | 6 |
| Cast-iron borings | | | | 1 | 17 | 0 |
| Wrot-iron piling | | | | 3 | 9 | 6 |
| Heavy machinery | 3 | 8 | 6 to | 3 | 10 | 0 |

London—Merchants' buying prices, delivered yard.

| | £ | s. | d. |
|---|---|---|---|
| Copper (clean) | 29 | 0 | 0 |
| Brass | 19 | 0 | 0 |
| Lead (less usual draft) | 14 | 0 | 0 |
| Tea lead | 9 | 0 | 0 |
| Zinc | 8 | 0 | 0 |
| New aluminium cuttings | 74 | 0 | 0 |
| Braziery copper | 27 | 0 | 0 |
| Gunmetal | 28 | 0 | 0 |
| Hollow pewter | 130 | 0 | 0 |
| Shaped black pewter | 100 | 0 | 0 |

## PIG-IRON

| | |
|---|---|
| N.E. Coast (d/d Tees-side area)— | |
| Foundry No. 1 | 77/6 |
| ,, No. 3 | 75/- |
| ,, No. 4 | 74/- |
| Forge No. 4 | 74/- |
| Hematite No. 1 | 85/6* |
| Hematite M/Nos. | 85/-* |
| N.W. Coast— | |
| Hem. M/Nos. d/d Glas. | 85/6* |
| ,, d/d Birm. | 97/-* |
| Malleable iron d/d Birm. | 125/- |
| Midlands (d/d Birmingham dist.)— | |
| Staffs No. 4 forge | 77/- |
| ,, No. 3 fdry. | 80/- |
| Northants forge | 74/6 |
| ,, fdry. No. 3 | 77/6 |
| ,, fdry. No. 1 | 80/6 |
| Derbyshire forge | 77/- |
| ,, fdry. No. 3 | 80/- |
| ,, fdry. No. 1 | 83/- |
| Scotland— | |
| Foundry, No. 1, f.o.t. | 81/6 |
| ,, No. 3, f.o.t. | 79/- |
| Cleveland No. 3, Glasgow | 78/- |
| ,, ,, Falkirk | 75/- |
| Scottish hem. M/Nos. d/d | 85/6* |
| Sheffield (d/d district)— | |
| Derby forge | 74/6 |
| ,, fdry. No. 3 | 77/6 |
| Lincs forge | 74/6 |
| ,, fdry. No. 3 | 77/6 |
| W.C. hematite | 91/-* |
| Lancashire (d/d eq. Man.)— | |
| Derby fdry. No. 3 | 83/- |
| Staffs fdry. No. 3 | 83/- |
| Northants fdry. No. 3 | 81/6 |
| Cleveland fdry. No. 3 | 83/- |
| Dalzell, No. 3 (special) | 102/6 to 105/- |
| Glengarnock, No. 3 | 90/- |
| Clyde, No. 3 | 90/- |
| Monkland, No. 3 | 90/- |
| Summerlee, No. 3 | 90/- |
| Eglinton, No. 3 | 90/- |
| Gartsherrie, No. 3 | 90/- |
| Shotts, No. 3 | 90/- |

* Subject to a rebate of 5s. per ton under certain conditions.

## FINISHED IRON AND STEEL

*Usual district deliveries for iron; delivered consumer's station for steel.*

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Iron— | | | | | | |
| Bars (cr.) | | | | 10 | 2 | 6 |
| Nut and bolt iron | 8 | 10 | 0 to | 9 | 0 | 0 |
| Hoops | | | 11 0 0 and up. | | | |
| Marked bars (Staffs) f.o.t. | | | | 12 | 10 | 0 |
| Gas strip | | | 11 0 0 and up. | | | |
| Bolts and nuts, ¼ in. × 4 in. | | | | 15 | 15 | 0 and up. |
| Steel— | | | | | | |
| Plates, ship, etc. | 9 | 7 | 6 to | 9 | 10 | 0 |
| Boiler plts. | 9 | 17 | 6 to | 10 | 0 | 0 |
| Chequer plts. | | | | 11 | 0 | 0 |
| Angles | | | | 9 | 0 | 0 |
| Tees | | | | 10 | 0 | 0 |
| Joists | | | | 9 | 7 | 6 |
| Rounds and squares, 3 in. to 5½ in. | | | | 10 | 0 | 0 |
| Rounds under 3 in. to ⅜ in. (Untested) | | | | 9 | 7 | 0 |
| Flats—8 in. wide and over | | | | 9 | 5 | 0 |
| ,, under 8 in. and over 5 in. | | | | 9 | 10 | 0 |
| Rails, heavy | 8 | 5 | 0 to | 8 | 10 | 0 |
| Fishplates | | | | 12 | 10 | 0 |
| Hoops (Staffs) | | | | 10 | 2 | 0 |
| Black sheets, 24g. (4-t. lots) | | | | 12 | 0 | 0 |
| Galv. cor. shts. ( ,, ) | | | | 14 | 0 | 0 |
| Galv. flat shts. ( ,, ) | | | | 14 | 10 | 0 |
| Galv. fencing wire, 8g. plain | | | | 15 | 0 | 0 |
| Billets, soft | | | | 6 | 2 | 6 |
| Billets, hard | 7 | 2 | 6 to | 7 | 7 | 6 |
| Sheet bars | | | | 6 | 0 | 0 |
| Tin bars | | | | 6 | 0 | 0 |

## PHOSPHOR BRONZE

| | Per lb. basis |
|---|---|
| Strip | 10½d. |
| Sheet to 10 w.g. | 11½d. |
| Wire | 12½d. |
| Rods | 11½d. |
| Tubes | 14d. |
| Castings | 12½d. |

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. Clifford & Son, Limited.

## NICKEL SILVER &c.

| | Per lb. |
|---|---|
| Ingots for raising | 7d. to 1/1 |
| Rolled— | |
| To 9 in. wide | 1/1 to 1/7 |
| To 12 in. wide | 1/1½ to 1/7¼ |
| To 15 in. wide | 1/1½ to 1/7½ |
| To 18 in. wide | 1/2 to 1/8 |
| To 21 in. wide | 1/2½ to 1/8¼ |
| To 25 in. wide | 1/3 to 1/9 |
| Ingots for spoons and forks | 7d. to 1/3½ |
| Ingots rolled to spoon size | 10d. to 1/6½ |
| Wire round— | |
| to 10g. | 1/4½ to 1/11½ |

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

## AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

| | Dols. |
|---|---|
| No. 2 foundry, Phila. | 21.31 |
| No. 2 foundry, Valley | 19.50 |
| No. 2 foundry, Birm. | 15.50 |
| Basic, Valley | 19.00 |
| Malleable, Valley | 19.50 |
| Grey forge, Valley | 19.00 |
| Ferro-mang. 80%, seaboard | 75.00 |
| O.-h. rails, h'y, at mill | 36.37½ |
| Billets | 30.00 |
| Sheet bars | 30.00 |
| Wire rods | 38.00 |
| | Cents. |
| Iron bars, Chicago | 1.80 |
| Steel bars | 1.95 |
| Tank plates | 1.90 |
| Beams, etc. | 1.90 |
| Skelp, grooved steel | 1.80 |
| Steel hoops | 1.95 |
| Sheets, black, No. 24 | 2.50 |
| Sheets, galv., No. 24 | 3.20 |
| Wire nails | 2.10 |
| Plain wire | 2.40 |
| Barbed wire, galv. | 2.60 |
| Tinplates, 100-lb. box | $5.25 |

## COKE (at ovens)

| | |
|---|---|
| Welsh foundry | 30/- to 31/- |
| ,, furnace | 24/6 to 25/- |
| Durham foundry | 24/6 |
| ,, furnace | 21/6 |
| Scotland, foundry | 30/- |
| ,, furnace | 25/- to 26/- |

## TINPLATES

f.o.b. Bristol Channel ports.

| | | | |
|---|---|---|---|
| I.C. cokes | 20×14 per box | | 18/9 |
| ,, | 28×20 ,, | | 37/6 |
| ,, | 20×10 ,, | | 26/9 to 27/- |
| ,, | 18¾×14 ,, | | 19/6 |
| C.W. | 20×14 ,, | | 15/9 to 16/- |
| ,, | 28×20 ,, | | 34/- |
| ,, | 20×10 ,, | | 22/9 |
| ,, | 18⅞×14 ,, | | 15/6 to 15/9 |

## SWEDISH CHARCOAL IRON & STEEL

| | £ | s. | d. | £ | s. | d. |
|---|---|---|---|---|---|---|
| Pig-iron | £6 | 0 | 0 to | £7 | 0 | 0 |
| Bars-hammered, basis | £16 | 0 | 0 to | £16 | 10 | 0 |
| Bars and nail-rods, rolled, basis | £15 | 15 | 0 to | £16 | 0 | 0 |
| Blooms | £10 | 0 | 0 to | £12 | 0 | 0 |
| Keg steel | £25 | 0 | 0 to | £28 | 0 | 0 |
| Faggot steel | £18 | 0 | 0 to | £23 | 0 | 0 |
| Bars and rods dead soft, st'l | £10 | 0 | 0 to | £12 | 0 | 0 |

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

## DAILY FLUCTUATIONS

**Standard Copper** (cash)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 38 2 6 | inc. 2/6 |
| „ 7 .. | 38 6 3 | „ 3/9 |
| „ 10 .. | 38 8 9 | „ 2/6 |
| „ 11 .. | 38 11 3 | „ 2/6 |
| „ 12 .. | 38 7 6 | dec. 3/9 |

**Electrolytic Copper**

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 42 0 0 | No change |
| „ 7 .. | 42 5 0 | inc. 5/- |
| „ 10 .. | 42 10 0 | „ 5/- |
| „ 11 .. | 42 10 0 | No change |
| „ 12 .. | 42 10 0 | „ „ |

**Standard Tin** (cash)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 184 0 0 | dec. 5/- |
| „ 7 .. | 182 10 0 | „ 30/- |
| „ 10 .. | 182 5 0 | „ 5/- |
| „ 11 .. | 185 5 0 | inc. 60/- |
| „ 12 .. | 184 5 0 | dec. 20/- |

**Tin** (English ingots)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 184 5 0 | No change |
| „ 7 .. | 183 0 0 | dec. 25/- |
| „ 10 .. | 182 5 0 | „ 15/- |
| „ 11 .. | 186 5 0 | inc. 80/- |
| „ 12 .. | 184 5 0 | dec. 40/- |

**Spelter** (ordinary)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 13 10 0 | dec. 7/6 |
| „ 7 .. | 13 8 9 | „ 1/3 |
| „ 10 .. | 13 7 6 | „ 1/3 |
| „ 11 .. | 13 7 6 | No change |
| „ 12 .. | 13 7 6 | „ „ |

**Spelter** (Electro, 99.9 per cent.)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 15 10 0 | dec. 7/6 |
| „ 7 .. | 15 8 9 | „ 1/3 |
| „ 10 .. | 15 8 9 | No change |
| „ 11 .. | 15 7 6 | dec. 1/3 |
| „ 12 .. | 15 7 6 | No change |

**Lead** (soft foreign, prompt)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 16 8 9 | No change |
| „ 7 .. | 16 15 0 | inc. 6/3 |
| „ 10 .. | 16 17 6 | „ 2/6 |
| „ 11 .. | 16 15 0 | dec. 2/6 |
| „ 12 .. | 16 12 6 | „ 2/6 |

**Lead** (English)

| | £ s. d. | |
|---|---|---|
| Aug. 6 .. | 18 10 0 | No change |
| „ 7 .. | 18 15 0 | inc. 5/- |
| „ 10 .. | 18 15 0 | No change |
| „ 11 .. | 18 15 0 | „ „ |
| „ 12 .. | 18 15 0 | „ „ |

## AVERAGE MONTHLY PRICES OF DERBYSHIRE NO. 3 FOUNDRY AT MANCHESTER.

| Year | Jan. | Feb. | March | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Yearly average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| 1900 .. .. | 4 0 0 | 4 0 0 | 4 0 0 | 4 1 6 | 4 1 0 | 3 18 0 | 3 13 6 | 3 12 6 | 3 11 0 | 3 11 0 | 3 9 6 | 3 8 0 | 3 15 5 |
| 1901 .. .. | 2 13 6 | 2 17 0 | 2 15 0 | 2 15 0 | 2 14 0 | 2 13 9 | 2 13 6 | 2 13 6 | 2 14 6 | 2 13 0 | 2 12 6 | 2 16 6 | 2 14 3½ |
| 1902 .. .. | 2 17 6 | 2 17 6 | 2 15 6 | 2 16 9 | 2 16 6 | 2 16 6 | 2 16 6 | 2 17 0 | 2 18 6 | 2 18 6 | 2 17 6 | 2 17 6 | 2 17 1½ |
| 1903 .. .. | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 |
| 1904 .. .. | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 | 2 17 6 |
| 1905 .. .. | 2 13 0 | 2 13 0 | 2 11 6 | 2 12 6 | 2 12 0 | 2 12 0 | 2 12 3 | 2 12 3 | 2 14 0 | 2 16 6 | 3 0 0 | 3 0 6 | 2 14 1 |
| 1906 .. .. | 3 2 0 | 3 5 0 | 3 3 0 | 3 0 6 | 2 17 0 | 2 18 6 | 2 18 0 | 2 16 6 | 2 19 0 | 3 0 6 | 3 1 6 | 3 7 0 | 3 0 8½ |
| 1907 .. .. | 3 7 0 | 3 7 0 | 3 5 0 | 3 2 0 | 3 4 0 | 3 8 0 | 3 6 0 | 3 5 0 | 3 4 0 | 3 2 6 | 3 1 0 | 2 18 6 | 3 4 2 |
| 1908 .. .. | 2 15 0 | 2 14 6 | 2 14 6 | 2 15 6 | 2 14 0 | 2 13 0 | 2 13 0 | 2 11 6 | 2 12 6 | 2 13 0 | 2 12 | 2 12 6 | 2 13 5½ |
| 1909 .. .. | 2 13 0 | 2 12 6 | 2 11 6 | 2 12 0 | 2 12 6 | 2 12 6 | 2 12 0 | 2 12 6 | 2 14 6 | 2 15 0 | 2 14 6 | 2 14 0 | 2 13 0½ |
| 1910 .. .. | 2 13 9 | 2 14 0 | 2 14 0 | 2 14 4 | 2 15 0 | 2 15 0 | 2 14 9 | 2 15 0 | 2 15 0 | 2 15 0 | 2 15 0 | 2 15 0 | 2 14 7½ |
| 1911 .. .. | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 16 0 | 2 14 6 | 2 15 0 | 2 15 0 | 2 15 8½ |
| 1912 .. .. | 2 17 4½ | 2 17 6 | 2 17 6 | 3 1 1½ | 3 2 6 | 3 3 9 | 3 6 3 | 3 7 6 | 3 10 10½ | 3 12 6 | 3 13 3½ | 3 14 6 | 3 5 4 |
| 1913 .. .. | 3 15 7 | 3 15 0 | 3 11 10½ | 3 11 4½ | 3 10 2½ | 3 6 10½ | 3 4 2½ | 3 2 9 | 3 1 9 | 3 1 0 | 2 19 3 | 2 17 2½ | 3 6 5 |
| 1914 .. .. | 2 17 2½ | 2 18 0 | 2 18 0 | 2 17 0 | 2 17 0 | 2 16 7½ | 2 16 0 | 3 2 10 | 3 1 0 | 2 19 9½ | 2 16 11½ | 2 18 1½ | 2 18 2 |
| 1915 .. .. | 3 1 2 | 3 3 11 | 3 5 9 | 3 18 8½ | 3 13 7 | 3 14 1 | 3 15 0 | 3 13 3 | 3 12 0½ | 3 11 1 | 3 14 0 | 4 3 3 | 3 12 2½ |
| 1916 .. .. | 4 4 6½ | 4 11 6 | 4 11 6½ | 4 7 6 | 4 7 6 | 4 7 6 | 4 10 0 | 4 12 10 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 8 6½ |
| 1917 .. .. | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 |
| 1918 .. .. | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 |
| 1919 .. .. | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 7 2 6 | 7 5 0 | 8 8 5 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 9 0 0 | 7 3 10 |
| 1920 .. .. | 9 13 9 | 10 0 0 | 10 5 3 | 10 15 3 | 11 10 0 | 12 2 6 | 12 5 0 | 13 1 3 | 14 7 6 | 14 5 0 | 14 5 0 | 14 5 0 | 12 12 1½ |
| 1921 .. .. | 12 11 8 | 10 8 9 | 9 2 6 | 8 2 0 | 8 0 0 | 8 0 0 | 8 0 0 | 8 1 8 | 7 4 0 | 6 7 6 | 5 7 6 | 4 14 10 | 8 0 2 |
| 1922 .. .. | 5 5 0 | 4 17 6 | 4 15 0 | 4 15 0 | 4 12 6 | 4 12 6 | 4 12 6 | 4 12 6 | 4 11 3 | 4 10 0 | 4 10 0 | 4 10 0 | 4 13 7½ |
| 1923 .. .. | 4 12 8½ | 5 0 2 | 6 2 6 | 6 8 7½ | 6 2 5 | 5 11 9 | 5 9 1½ | 5 4 0 | 5 0 0 | 5 0 9 | 5 0 7 | 5 2 9 | 5 7 11½ |
| 1924 .. .. | 5 3 0 | 5 3 0 | 5 3 0 | 5 3 0 | 5 2 10 | 5 1 3 | 4 17 11 | 4 15 6 | 4 13 6 | 4 10 1½ | 4 10 0 | 4 10 3 | 4 17 9½ |
| 1925 .. .. | 4 10 0 | 4 9 0 | 4 6 9 | 4 5 2½ | 4 3 0 | 4 0 1½ | 4 17 1½ | 3 15 7½ | 3 14 3½ | 3 13 4½ | 3 13 4½ | 3 13 2½ | 4 1 9 |
| 1926 .. .. | 3 14 9 | 3 15 3 | 3 15 6 | 3 15 3½ | 3 17 6 | 4 5 9 | 4 16 9 | * | * | * | * | 4 12 6 | 4 0 1½ |
| 1927 .. .. | 4 13 9½ | 4 13 3 | 4 11 1½ | 4 9 4½ | 4 6 1½ | 3 10 1½ | 3 16 1½ | 3 15 6 | 3 13 4½ | 3 13 4½ | 3 14 0 | 3 13 6½ | 4 1 6½ |
| 1928 .. .. | 3 13 2½ | 3 12 3½ | 3 12 3 | 3 12 3 | 3 11 8 | 3 10 0 | 3 8 3 | 3 7 8½ | 3 7 6 | 3 7 9½ | 3 8 3 | 3 7 6 | 3 9 10½ |
| 1929 .. .. | 3 8 3½ | 3 10 4½ | 3 10 10½ | 3 11 0 | 3 11 2½ | 3 12 0 | 3 12 4½ | 3 14 6 | 3 15 1½ | 3 17 0 | 3 17 0 | 3 17 0 | 3 13 1½ |
| 1930 .. .. | 3 17 0 | 3 17 0 | 3 17 0 | 3 17 0 | 3 17 0 | 3 17 0 | 3 15 0 | 3 12 0 | 3 12 0 | 3 12 0 | 3 10 1½ | 3 9 6 | 3 14 4½ |
| 1931 .. .. | 3 9 6 | 3 9 6 | 3 9 6 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 10 |
| 1932 .. .. | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 |
| 1933 .. .. | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 | 3 7 0 |
| 1934 .. .. | 3 7 0 | 3 9 6 | 3 13 2½ | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 12 11½ |
| 1935 .. .. | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 14 0 | 3 18 0 | 3 18 0 | 3 14 8 |
| 1936 .. .. | 3 18 0 | 3 18 0 | 3 18 0 | 3 18 0 | 3 18 0 | 3 18 0 | 4 3 0 | — | — | — | — | — | — |

* No prices available during strike period.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IRONFOUNDRY FOREMAN seeks change or position as Assistant Manager. Age 28. Experienced in Jobbing and General Engineering. Sound Technical Education. Technical College Senior Diploma. 1st Class City & Guilds Certificate.—Box 834, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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*Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.*

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IRONFOUNDRY Foreman desires position with progressive firm. Experienced in jobbing work, machine moulding, general engineering, estimating, cupola practice, etc. (283

### BUSINESS FOR SALE

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'PHONE **98** STAINES.

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